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PREPARATORY SKETCH OF THE NEW U. S. PROTECTED CRUISERS OF THE DENVER CLASS.

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CHARACTERISTICS OF THE NEW PROTECTED CRUISERS OF THE DENVER CLASS.

Under the provisions of the Naval Appropriation bill passed by the last Congress, six new cruisers for the United States Navy will soon be under construction at various yards on the coasts. Through the courtesy of the naval authorities we are able here to present to our readers the chief characteristics of these interesting vessels. Their names have already been selected, and they will be known, respectively, as the *Denver, Des Moines, Chattanooga, Galveston, Tacoma* and *Cleveland.* In one respect these ships will be a radical departure from previous practice in the United States Navy, as they will be sheathed and coppered; and in other respects they will, of course, be strictly up to date and the equal, if not the superior, of anything of their size afloat. These new vessels are now referred to as belonging to the *Denver* class, this being a ready aid to the memory in recalling the dimensions, etc., of any one of the six when they are mentioned.

For many years Chief Constructor Hichborn, U. S. N., stood almost alone in his advocacy of sheathing for ships' bottoms, but persistent argument, combined with many object lessons from the reports of our ships in service, which tended to prove the statements in favor of sheathing, have at last overcome the strong prejudice against it, and all of the twelve ships authorized by the last Congress—three first-class battleships, three first-class armored cruisers, and the six protected cruisers here described—are to be sheathed and coppered.

On account of the Congressional limitation of the price which the Department may pay for armor, and the improbability of being able to get any armor at that price, the six ships of the *Denver* class are the only vessels for which contracts can be made without further action by Congress. Designs for these ships are now being rapidly perfected by the Bureau of Construction and Repair. They will be vessels of about the size of the *Raleigh* and *Cincinnati,* but improved and modernized. The latter ships were designed at the time when the craze for speed at all costs reached its maximum, and to attain this extreme speed, which it will be noted could only be maintained for a few weeks after they were docked and cleaned, on account of their rapidly fouling unsheathed bottoms, too many other qualities were sacrificed, and they are now being altered to remedy this defect. The *Denver* and her sister ships are designed for a speed of 16 1-2 knots, but will only make 17 knots when pushed, while the *Raleigh* and *Cincinnati* were designed for a speed of 19 knots. The former will be able to maintain their designed speed practically indefinitely, while the latter in actual service could scarcely maintain a speed of 15 knots, and that with an excessive consumption of coal. The horse power required in the new designs is 4,500 as compared with 10,000 in the *Raleigh* and *Cincinnati,* which means less than half the weight of propelling machinery.

The guns will all be designed for smokeless powder, and the 5-in. guns will be more effective than the old type of 6-in guns. Eight of them will be mounted on the main deck in recessed ports: the four forward ones having a range from right forward to 60 degrees abaft the beam, and the four after ones from right aft to 60 degrees before the beam. The two remaining 5-in. guns will be mounted behind shields on the spar deck: one forward and one aft. Four 6-pounders will be mounted on the main deck: two forward and two amidship, and four more on the spar deck. The two 1-pounder guns will be mounted aft on the main deck, and the Colt machine guns on the top of the hammock berthing amidship.

The general dimensions and features of the *Denver* and class will be as follows:

Length on load water line	292 ft.
Length, extreme	308 ft. 2 in.
Breadth, extreme, about	43 ft.
Mean draft at trial displacement; two-thirds coal, ammunition and stores	15 ft. 6 in.
Extreme draft fully loaded	16 ft. 8 in.
Trial displacement, about	3,100 tons.
Full load displacement, about	3,400 "
Coal carried on trial	470 "
Total bunker capacity, not less than	700 "
Speed on trial	16 1-2 knots.
Type of engines: Vertical inverted, four-cylinder, triple-expansion. Estimated indicated horse power	4,500
Type of boilers: Water-tube. Number of boilers	6

MAIN BATTERY.

Ten 5-in. 50-cal. B. L. R. F. guns.

AUXILIARY BATTERY.

Eight 6-pounder R. F. guns.
Two 1-pounder R. F. guns.
Four Colt machine guns.

Sail area, about	6,000 sq. ft.

The coal capacity of these ships with bunkers full (700 tons) is sufficient to give them a radius of action at full speed of about 2,600 miles. At the most economical rate of steaming, probably in the neighborhood of 10 knots per hour, they will be able to steam about 9,800 miles without recoaling, or more than sufficient to take them from San Francisco to Manila. The ammunition supply will be large, as it should be to make rapid-fire guns effective. For each of the 5-in. guns they will carry 250 rounds, and for each of the 6-pounders, 500 rounds.

The wood material used in the construction of the hulls will be reduced to a minimum. All the bulkheads on the gun and berth decks will be of metal. Each vessel will be fitted with a pilot house on the spar deck built entirely of non-magnetic metal. Where it is necessary to use wood for any purpose, it will be treated with the electric fireproofing process before being worked. A watertight deck covered with 1-2 in. plate will be worked from stem to stern, the sides sloping down to 3 ft. below the water line, and the flat or midship portion rising 18 in. above the water line. This will be on the line of the berth deck for the greater part of the length, but toward the ends it will slope down. On top of the watertight deck at the sides a belt of obdurating material will be worked, covering the water line for the whole length of the ship. All of the propelling machinery, steering gear and magazines will be below the watertight deck. The rig will be two-masted schooner, with signal yards on the foremast.

Each vessel will have two searchlights, an electric signaling system, and a complete installation of electric lights. The blowers for ventilation and deck winches will be operated by electricity.

FROM FURNACE TO PROPELLER—A HISTORY OF THE ENERGY LOSSES WHICH OCCUR ON THE WAY.

BY EDMUND LEAVENWORTH.

The fireman wields the shovel—the propeller turns and the ship speeds on her course. Here we have a cause and its effect standing, respectively, at the head and foot of a long series of operations. With the history of these operations the marine engineer is most deeply concerned. Let us trace then some of the steps which lead from the fireman and the coal which he throws on the fire, to the propeller and the ship which it urges through the water.

We must, at the start, clearly understand that it is with *energy* and *work* and the history of their journey from the coal to the propeller that we are concerned. These words energy and work, or more especially the first, may suggest mechanics and mathematics, but we shall have small use for either in this discussion, except in the most simple form. In any event, energy is simply the name of the capacity for doing work, and the engineer, if any one, should surely be acquainted with such a capacity in any and all its forms. Thus a lump of coal represents simply a certain amount of energy, or the capacity to do a certain amount of work, and the whole engineer's equipment on board ship exists simply in order that as much as possible of the energy may actually be converted into the desired work of propelling the ship. Unfortunately this result, so easy to state in words, requires a long series of transformations or changes of form, and transportations or changes of place, in all of which more or less is lost by the way. In fact, the engineer's life is one long struggle against the tendency of energy to escape in some way or other, and so to avoid the transformation into useful work. Energy and work are, in fact, such peculiar commodities that it is next to impossible to effect any change either of form or place without some loss, and quite impossible to effect certain of the changes which are necessary without very serious loss. It is the history of these changes and losses which befall the energy on its way from the coal to the propeller that we are now to examine.

Let us first understand that coal is not energy, neither does it by itself possess energy. It is simply a substance whose union with oxygen results in *liberating* energy—from where we will not here ask. That is another story. It is enough for the engineer to know that when coal unites with oxygen, or *burns*, as we commonly say, energy is liberated in the form of heat, and it is then his duty to use it as best he may. The burning or combustion is accomplished in the boiler furnaces, where the oxygen supplied by the air unites with the carbon and hydrogen in the fuel, and heat energy is set free. Suppose now that we start with one pound of good coal. Then experience shows us that if this pound of coal were perfectly and completely burned, and so all the heat available from it were liberated, there would be about 14,000 heat units; that is, 14,000 times as much as the heat required to raise one pound of water one degree, or, more exactly, from 62° to 63° Fah. Now, let us call this amount of heat 100 per cent, and represent it by the rectangle *ABCE* in the diagram on page 5. This amount we must then consider as our total available energy, our entire stock in trade for producing the propulsion of the ship. It is evident then that the first step should be the complete combustion of the fuel, for if it is not complete a corresponding loss will result. If the energy is not liberated it can never be used. If it is lost here it can never be regained. As a matter of fact, however, it is impossible to obtain absolutely complete combustion, and it is just here that the first loss comes in. A little of the fuel may fall unburned through the grate into the ashpit. A little in the form of dust and small bits may be carried by a strong draft, either unburnt or only partially burnt, through into the tubes, uptakes or funnel. Still another small portion may escape as smoke, which consists almost entirely of very fine particles of unburnt carbon formed from the gases which are distilled away from the coal in the process of combustion. Still another portion of these gases may escape entirely unchanged and unconsumed. Again, another portion of the energy may escape with a particular gas containing partially burned carbon. Chemistry teaches us that carbon and oxygen in burning may unite in two ways. One of them forms what is called *carbon monoxide*, and gives only about 4,450 heat units per pound of carbon. The other forms what is called *carbon* dioxide, and gives 14,500 heat units per pound of carbon. Hence whatever carbon escapes in the form of carbon monoxide is only partly burned, and we may consider it as carrying away over two-thirds of the energy which should be ours, and which would be by a complete combustion.

These losses in the furnace are due, therefore, to poor firing and incomplete combustion. To reduce them to the smallest possible limit the fireman must know his business, and be willing to properly attend to it. In addition, there must be provided, by proper design, the necessary supply of air both above and below the grate, together with such other arrangements as experience may show are needed for good combustion with the fuel in hand. Still, try as we may, there will be some loss, though with care and good design it may be reduced to perhaps not more than 2 or 3 per cent, or even less. With carelessness and poor design, however, it may reach a very serious amount, 10 to 20 per cent being no unusual figure for such conditions.

For illustration we will take this loss at 4 per cent, and represent it by the little rectangle *DEFG*. Then the remaining part, *CDGI*, will likewise represent the total amount of heat actually liberated. In the present case this amount is 96 per cent of the whole. This fraction is usually called the *efficiency of the furnace.* That is, if we consider it the office of the furnace to liberate all of the heat by complete combustion, then the fraction which is actually liberated is naturally called the furnace efficiency. In the present case this would be then 96 per cent.

We next consider that the furnace should pass this heat over to the boiler heating surface, whose office it is to transfer it through into the water on the other side. This is one of the series of changes to which the energy is to be subjected. It is still retained in the form of heat, but is to be given from the hot gas to the water which it transforms into steam. This change is

effected simply because water or steam is more convenient than hot gas for use in an engine for obtaining mechanical work. It is the office then of the heating surface to pass the heat from the hot gas formed by the combustion of the coal through into the water. This, however, cannot be completely accomplished, and here comes in the second loss. A part of the heat, instead of getting through the heating surface, goes up the funnel with the escaping gases, and so gets away into the outside air, and thus beyond all reach of use in the formation of steam. Another and much smaller part escapes by radiation out into the fire-room. These losses of heat it is impossible wholly to avoid. It would be necessary to prevent all loss of heat by radiation into the fire-room, and to reduce the temperature of the products of combustion in the funnel to that of the outside air. The latter especially cannot be done for a variety of reasons. In the first place their temperature cannot be reduced below that of the steam and water in the boiler, because heat always flows naturally from a hot body to a cooler one, and it will therefore flow from the gas to the water only so long as the latter is the cooler of the two. Actually the temperature of the escaping gases will be much higher than the steam, because in the first place sufficient heating surface to reduce them nearly to the same temperature could hardly be afforded; and again, aside from blowers, the strength of draft is dependent on the temperature of the hot gas in the funnel, and for a satisfactory rate of combustion it is necessary to discharge the products of combustion at a temperature of from 500 to 700 degrees. This loss is one, therefore, which exists in the very nature of things, and in the usual case cannot be reduced below from 20 to 25 per cent. No definite figures can be given for the loss by radiation into the fire-room, but it would be very small, and, in any ordinary case, quite inconsiderable in comparison with that which we have just discussed. In the present case, for illustration, we will take this second series of losses at 24 per cent. Reckoned on the original base, this will be 24 per cent of 96 per cent, or about 23 per cent of the whole. In the diagram let this be represented by *GHLM*. Then the amount of heat energy which traverses the heating surface and takes part in the formation of steam is 73 per cent of the whole, represented by *HIJL*. The fraction *GHLM* ÷ *GIJM* gives the percentage of loss, and *HIJL* ÷ *GIJM* gives the percentage transferred. This is usually called the efficiency of the heating surface, and would here equal 76 per cent. The total area $FHLC_1$ represents the total loss to this point, or 27 per cent of the whole, while the fraction *HIJL* ÷ $FIJC_1$, or 73 per cent, is called the efficiency of the boiler.

We come now to the third step in our series of operations. The steam, carrying with it the heat energy which it has received, is to be transported along a pipe and given over to the engine. A part of the heat escapes, however, by radiation from the boiler and steam pipe, resulting in the condensation of part of the steam back into water again. Here, then, is another loss whose amount will depend on the length of the pipe, and whether bare or covered with non-conducting material. By properly covering or lagging the boiler and pipe with non-conducting material this loss may be reduced to a very small amount, while with a long bare pipe it may become very considerable. In the present case we will take the amount at one per cent of the heat in the steam. Let this be represented by the rectangle *KLNO*. This, referred to the original amount as a base, will be 1 per cent of 73 per cent, or .73 per cent. The remainder represented by the rectangle *JKOQ* is the energy which finally reaches the steam chest and is handed over to the engine, amounting to 73—.73, or 72.27 per cent. Similarly the rectangle KC_1D_1O represents the sum of all the losses to this point, the amount of which will be 4 + 23 + .73, or 27.73 per cent.

We come now to the fourth step in our history, involving the most important of the various operations, and the most serious of all the losses. The energy which has so far been in the form of heat, is now to be transformed into mechanical work in the engine. In effecting this a most serious loss necessarily occurs. This comes about in two ways. First; when heat is transformed into mechanical work, even the most perfect engine possible is unable to effect the change without a large loss. Second; the actual steam engine falls far short of attaining to the possibilities of this ideally perfect engine. With such an engine the fraction of the heat which can be changed into work is expressed by the difference between the highest and lowest temperatures of the steam, or other working substance, for the numerator, and the highest temperature plus 460.7 for the denominator. Thus, for example, if the steam enters at a temperature of 350° and exhausts at a temperature of 130°, the fraction is 220 ÷ 810.7, or about 27 per cent. That is, only about one-quarter of the heat is transformed into work, nearly three-quarters being utterly lost in the operation. And this is the very best that could be done between these temperature limits by the most ideally perfect engine possible. Practically such an engine cannot be built, although the conditions which must be fulfilled are simply stated, and are as follows: The whole operation must consist of four parts. During the *first* the working substance should receive all the heat which is to be given it. During the *second* it should be allowed to expand, but without giving up or receiving any heat. During the *third* all the heat should be removed which is to be taken from the substance. During the *fourth* it should be compressed under such conditions that it shall neither give up nor receive any heat, and shall finally come back to its original condition of volume pressure and temperature. The operation is then repeated in successive similar rounds or cycles. As before stated, no such engine can be practically constructed, and no actual engine can fulfil these conditions, or reach the corresponding efficiency. In fact, the actual engine works on a cycle of operations quite different from those specified above. Into the details of these variations we cannot here enter, but in consequence of them the actual engine is only able to realize from 60 to 80 per cent of the efficiency of the ideally perfect engine as given in the foregoing. This gives then from 15 to 20 per cent as the engine efficiency for good practice with triple or quadruple expansion engines using from, say, 17 to 12 lbs of steam per I. H. P. per hour. This covers the range of what may be called good practice.

This loss, then, of from 80 to 85 per cent of all the heat coming to the engine is due partly to the very nature of the operation, and partly to our inability to realize the most favorable conditions. Increase of pressures, decrease of clearance, the use of jackets, reheaters, superheaters, etc., may all tend toward a reduction of this loss, but at the very best the amount of improvement which can be hoped for is but slight in comparison with the amount of the loss itself. In the present case for illustration, we will suppose that the loss at the engine is 83 per cent of the heat provided by the steam. This referred to the original amount as a base will be 83 per cent of 73.27 per cent, or 60 per cent. Let this be represented by the rectangle *OPTU*. The remainder represented by the rectangle *PQRT* is the amount transformed into mechanical work developed in the cylinders, amounting to 72.27 — 60 = 12.27 per cent. Similarly the rectangle PD_1E_1T represents the total loss to this point, the amount of which will be 4 + 23 + .73 + 60 = 87.73 per cent. The ratio of the rectangles $IQRT \div OQRU$, or 17 per cent, represents the efficiency of the engine, while the ratio $PQRT \div QD_1E_1R$, or 12.27 per cent, represents the efficiency of the whole operation of this point.

The amount of work thus developed in the cylinders we commonly call the I. H. P. or indicated horse power. This work has now to be passed along to the propeller, and here a further loss arises. Friction in the engine and shaft bearings is always present to absorb its share of the work, and only the remainder is finally delivered to the propeller. The action of friction in thus absorbing work is familiar to us all. This resistance is met with wherever there is a rubbing or turning joint—between the pistons and cylinders, in the stuffing boxes, cross-heads and crank-pins, valves and valve gear, crank, line and thrust-shaft bearings, and stern tube. At all of these points a resistance is encountered and a little of the work developed is lost. The reduction of this loss requires special attention to workmanship and lubrication, but at the best we cannot expect to reduce it below about 10 or 12 per cent, while under poorer conditions it may readily rise to 15 or 20 per cent. In the present case we will take the amount at 13 per cent of the I. H. P. This referred to the original amount as base will be 13 per cent of 12.27 per cent, or 1.60 per cent. Let this be represented by the rectangle *STVW*. The remainder *KSWY* represents the delivery to the propeller, amounting to 10.67 per cent. Similarly the rectangle SE_1F_1W represents the total loss to the point, amounting to 4 + 23 + .73 + 60 + 1.6 = 89.33 per cent. The ratio $RSWY \div RTVY$, or 87 per cent, represents the mechanical efficiency of the engine, while the ratio $RSWY \div RE_1F_1Y$, or 10.67, is, of course, the efficiency of the whole operation to this point.

We now come to the last operation and last loss in our series. The work delivered to the propeller is not all utilized by it in driving the ship ahead. The *useful work of propulsion*, that which would correspond to the work of towing the ship at the given speed, is usually from 65 to 70 per cent of the work delivered to the propeller. The remaining 30 to 35 per cent is spent on the water in giving it sternward motion and in churning it into eddies and whirls, and in doing work which results from the interaction between the ship and the propeller. This loss likewise is one which exists in the very nature of the operation, and we cannot hope practically to reduce it much below the smaller amount before mentioned. For the best results obtainable we require a propeller of proper form and specially designed to suit the given conditions, having in view all the special circumstances of the case. With a poorly designed propeller the loss may rise to 40 or 50 per cent or even more.

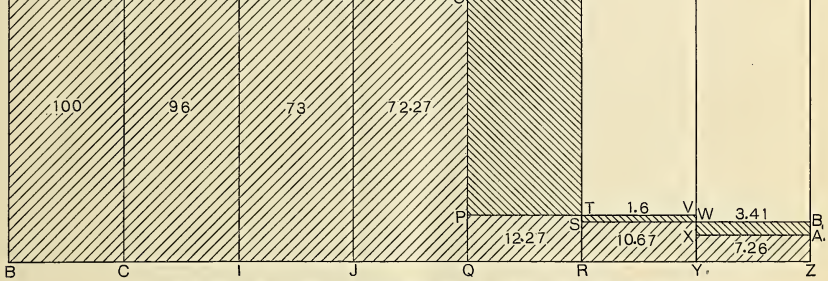


DIAGRAM SHOWING GRAPHICALLY ENERGY LOSSES FROM FURNACE TO PROPELLER.

In the present instance we will take such loss at 32 per cent of the work supplied. This referred to the original amount as base will be 32 per cent of 10.67 per cent, or 3.41 per cent. Let this be represented by the rectangle WXA_1B_1. The remainder $XYZA_1$ represents the finally useful propulsive work, amounting to 7.26 per cent. Similarly the rectangle $XF_1G_1A_1$ represents the total loss, amounting to 4 + 23 + .73 + 60 + 1.6 +

3.41 = 92.74 per cent. The ratio $XYZA_1 \div WYZB_1$, or 68 per cent, might be considered as the propeller efficiency, though as here defined, it is rather an efficiency depending on both ship and propeller and their mutual interaction.

Referring now to the diagram in general, the successive rectangles hatched downward and to the left show the successive values of the useful energy as it progresses through the various stages on its way from the coal to the propeller. The numbers within the rectangles show the values resulting from the various losses selected for illustration in the present case. As already noted, such values are subject to considerable variation in different cases, but those given may be taken as showing fairly good practice with triple expansion engines and steam pressures from 150 to 180 lbs. The rectangles hatched downward and to the right represent the individual losses with amounts as indicated just above them, while the whole rectangle from the lower side, as PT to the top of the figure D_1E_1, represents at any stage the total loss up to that point in the process.

In the present case we have for simplicity followed through the operations for the main engine alone, and omitted reference to the auxiliaries. For the independent auxiliaries a part of the steam is directly used for their operation, and we should have a series of special histories for each, similar in nature to that for the main engine, but differing in detail according to the character of the auxiliary engine, and the work it is required to perform. For the attached auxiliaries, if there are such, a part of the power developed in the main engine is required for their operation, the remainder going on to the propeller as described in the foregoing. These variations involve, however, nothing different in principle, and for simplicity the detailed discussion and diagram were limited to the consideration of the main engine alone.

What then is the final result? 7.26 per cent saved out of 100 available at the start—about 1 part in 14, or 1,000 heat units per lb. of good coal out of the 14,000 which it has available. This seems like a disheartening result, but such should never be the attitude of the engineer. He must realize that these losses are the result of the laws of Nature, as we are at present able to interpret them. He is not to blame himself for inability to overcome a law of Nature, but rather only for neglect to make the most of the possibilities under these laws as they are understood. Let us, then, as engineers, realize our duties and privileges in this light, and within the limitations which surround us, work for the decrease of this constant chain of losses which invariably attend every operation with energy.

S. S. Alaska—The sale of the famous old Guion liner *Alaska*, known in her prime as the "Greyhound" of the Atlantic, has been reported sold for about $90,000 for breaking up. She was built less than twenty years ago at Govan on the Clyde in the yard of John Elder & Co., now the Fairfield Shipbuilding Co., and was a remarkable vessel. When the Guion line went out of business she was laid up in the Clyde and has not been in regular service since.

REMINISCENCES OF EARLY MARINE STEAM ENGINE CONSTRUCTION AND STEAM NAVIGATION IN U. S. FROM 1807 TO 1850.*

BY CHARLES H. HASWELL, M.E.

In some reminiscences of early marine engine construction and steam navigation in the United States, presented recently to the Institution of Naval Architects of Great Britain, the writer stated that down to 1822 the engines were of the vertical crosshead type, connected with sliding clutches directly to the water-wheel shafts, and also geared to a shaft with a fly wheel at each end of it. The object of the connection was to enable the water wheels to be disconnected and the engine operated independently to feed the boiler and operate the bilge pump when the vessel was at a pier or anchored, as independent steam, feed, bilge and fire pumps were then unknown. The steam and exhaust valves, if puppet, were operated by the hand gear of Beighton; when otherwise, the long slide valve was used.

This type of engine, with the crosshead, connecting-rods, cranks and shafts of cast iron, the key, crank and pin holes cored and cast in, was wholly used until about 1822, when the vertical overhead beam was introduced, and when the horizontal or inclined engine was introduced the short slide valve was resorted to, except in the southern and western waters, where the lever puppet, operated by a cam, was wholly employed.

The boilers, with the exception of the very first few, which were plain cylindrical, set in masonry, were of copper plates of the design termed "D. and Kidney Flue," having but one furnace, the full width of the inner space of the front, the flame and gases of combustion leading through a flue of about two-thirds the width of the furnace into a back connection, and thence into a return flue, which, from the outlines of its transverse section, was termed a "kidney flue." From this they were led to a short vertical flue at the back of the furnace, and then extending up to the shell of the boiler, in a short shoulder of which the base of the smoke pipe was set. The cause of this convexity to the inner side of the main flue, and the indentation given to the inner side of the other, was because the curved surfaces rendered the socket bolts of plain surfaces unnecessary, with the limited steam pressure of 15 lb. or less per square inch.

In southern and western waters, where non-condensing engines were resorted to because the waters of the rivers were too turbid for the continuous operation of a condenser, wrought iron cylindrical boilers alone were used and the character of the iron was such that the plates were cold riveted. They were generally internally fired, in some cases externally, and it was not until about 1820 that marine boilers were constructed of iron in eastern waters.

BOILER PLATES.

Boiler plates were punched manually by the aid of a long wooden lever, on which four men exerted their power, and as the location for the punch was directed only by the eye of the operator, the spaces were frequently irregular, involving pinning, in order to bring

*A paper read before the Institution of Naval Architects in London.

the holes as nearly opposite as practicable, and, hence, the plates were frequently strained and the rivets set at an inclination. All of the latter were hand made, but in the East they were driven hot.

BLOW OFFS.

Blow offs were not attached to boilers until steam navigation was well advanced. The exact period is not now ascertainable—probably about 1822. The boilers of steamboats on the bay and river routes, with the low pressure, and the consequent low temperature, of steam with which they were operated, did not involve the necessity of the frequent blowing off of saturated water from their boilers, and the water was allowed to run out of them at the end of each passage. They were then refilled with fresh water. In consequence of this neglect of blowing off, and the imperfect manner in which the plates were riveted, a boiler at the end of a trip in wholly, or even partially, salt water would be loaded in its seams and joints with incrustations and stalactites of salt to an extent that involved their being hammered and scraped off. Felting of a boiler was unknown.

FINISHING.

So deficient were the facilities of lathes, planers, slotters and drills that "black work" of engines, as it was termed, was the prevailing finish. The connecting-rod of a large vertical beam engine in the *Victory* was wholly finished in the smith's shop, its body, after forging, being dressed by swaging, the key holes drifted, and the ends and straps dressed with a flatter on an anvil, and a horse file.

CYLINDER PISTON PACKING.

Cylinder piston packing consisted of hemp gaskets, and if the safety valve of the boiler was not raised during the initial raising of steam, the steam around the chimney flue would become so dry as to char the wood blocking between the ribs of the piston, and also the piston packing; hence lead pipes, through which the gaskets were drawn, were resorted to.

ACCESSORIES.

Counters, indicators, salinometers, brine pumps, steam and vacuum gauges, metallic packing, whistles, and oil cups other than the one in the cylinder head, by which the piston was lubricated on its exhaust side, were unknown.

COMPOUND OR WOLF ENGINE.

About 1824 James P. Allaire, of New York, constructed the steamboat *Henry Eckford*, with a vertical crosshead compound engine, the center shafts geared to the wheel shafts; but, in the absence of a receiver, the mutual operations of the cylinders were only at the extreme of the opposite strokes of their pistons. Soon after, and up to 1828, he constructed five other boats, namely, the *Sun, Commerce, Swiftsure* and *Pilot Boy*, with like engines, and the *Post Boy* with an overhead beam engine, the cylinders being set at its opposite ends; but as this type of compound engine operated at the moderate pressure of 25 lb. per square inch, it did not attain such an effect as to justify the increased cost and weight of two cylinders and their connection, and its further construction was abandoned.

STEAM CHIMNEY.

In 1827 Mr. Allaire invented the steam chimney. The original design was that of two cylinders of boiler plate, one within the other, connected and closed at both ends, the inter-space being about 5 in. in width, with a vertical diaphragm, connected near its upper end to the outer shell above, where steam was admitted from the boiler through two or more connecting pipes. These served also as fastenings and to hold the chimney in position. This diaphragm led down to within a few inches of the bottom of the chimney, and the steam was inducted down and under it, then up and around the inner cylinder, and thence to the steam pipe opening in the top; thus the steam deposited its contained water in the chimney, to be vaporized by the heat at the base, and received also heat from that ascending the chimney; hence a material economy of fuel was attained with the advantage of obtaining dry steam. Boilers at this period did not foam (prime); the great proportionate volume of water, its area at the water line, and the moderate heat in the furnace, from wood, with but a natural draft, precluded it.

BREAKDOWN.

In 1828 the engine of a large steamboat, the *Chief Justice Marshall*, on the route from New York to Albany, broke down by the breaking of the head of her piston rod at its insertion into the crosshead socket; the crosshead, both connecting-rods, and a center crank were broken, and in four days new castings from the builder's patterns were made, the piston rod was repaired, all fitted, and the engine was ready for operation.[1]

In this connection it is to be considered that neither the eye of the crank was reamed nor the key holes of the rods slotted; the crank eye and the ends of the rods were submitted only to the operation of a coarse file.

ATTACHMENTS TO ENGINES.

In the attachments to engines and boilers the steam gauges were constructed in the smith's shop, and consisted of an iron tube half an inch in diameter and 4 ft. in length, bent, with one of its legs 15 in. in the clear in length, and in the other the balance of its length was filled with mercury, on which was placed a light pine rod, the rise and fall of which, shown on a tin plate divided and numbered in inches, designated the pressure of the steam in pounds per square inch.

EARLY STEAM NAVIGATION.

Steam navigation, up to the latter part of 1839, was confined to Long Island sound, the southern and western rivers, and Canadian lakes and rivers, with a single passage of a steamboat from New York to Philadelphia, the *Phœnix*, in 1807, and one on the route from Havana to Matanzas, and one from Charleston to Savannah. In 1819 the auxiliary steamer *Savannah*, of 380 tons, steamed and sailed from Savannah to Liverpool, she being the first steamer to cross the Atlantic ocean.

In 1825 Mowatt Brothers, of New York, owners of the steamboat *Henry Eckford*, attached a loaded barge to her, and transported it from New York to Albany; this was the first essay of steam towing, and, although its insufficiency and impracticability were generally predicted, the enterprise proved to be a great and lasting success.

In 1826 a fan blower was first introduced under the

[1] Witnessed by the writer.

grates of the boilers in the steamboat *North America*, of the Messrs. John C. & Robert L. Stevens.

In 1828-1829 the rivalry for speed between the steamboats plying on the route from New York to Albany was so great that, in the design of the boats, their beam was disproportionate to the weight of the engine, boilers and deckhouses above, and they proved unstable. In order to reduce this condition large logs of light pine wood with sharp ends were firmly suspended under the after wheel guards and depressed for half their diameter below the water line, and in operation they measurably improved the stability of the boat.

In 1830 the patent of the steam chimney of Mr. Allaire was invaded, and its operation simplified by making the double cylinder an integral part of the boiler, open at its lower end, and extending to such a height above the boiler as to give the necessary surface to superheat the steam. The height and volume of steam space helped measurably to arrest foaming, by admitting the subsidence of the water physically borne with the steam in its flow to the steam pipe.

Gongs for the engine-room were unknown, and in many of the boats, when the pilot was in his house (if there was one) or on the deck over the engine-room, he would signal to the engineer by the strokes of a stick or cane upon the floor of the house or deck.

All boats, of course, carried bells, and by them all notices of departure and of arriving were made known, and all salutes between boats were given by their bells. To blow steam, as is now done by a whistle, was intended to be a challenge or an insult.

In July, 1837, the first steam launch, the *Sweetheart*, 35 ft. long, 4 ft. 3 in. beam, and 3 ft. depth, engine 4 by 12 in., wheels 3 ft. 6 in. dia., and boiler horizontal fire-tubular, designed and constructed at the United States Navy Yard, New York, by the writer, then chief engineer of the Navy, was completed, and on her trial and succeeding trips around the city of New York was saluted with the bells of passing steamboats and cheered by people who rushed to the ends of the piers to witness the novel sight. She attained a speed of 8.5 miles per hour. The engine was subsequently transferred to the United States Naval School at Annapolis.

Fuel, up to the year 1836, was wholly pine wood, though up to that time some owners of steamboats commenced experimenting upon the practicability of using anthracite coal. A steamboat on her route of six or more hours could not have the capacity in her fire-room to contain all the wood required, and was compelled to pile it upon her side houses; and such boats as were on a long route, as from New York to Providence, were compelled to invade their upper deck with wood, and upon leaving the city had somewhat the semblance of a floating woodyard.

In 1836 James P. Allaire commenced the running of a steamboat, the *David Brown*, a light-built river boat with deck-houses and promenade deck, from New York to Charleston, S. C., and return, the enterprise being almost universally held to be utterly impracticable. It was successful, however, and soon afterward he built two other and larger boats for the same route, and from that period coastwise steam navigation was held to be so practicable that various lines to other ports were established. The *David Brown* was fitted for this new service with planking under her water-wheel guards, closely joined and caulked, extending from the inside of the string piece to the light water line, which shielded the guards from being forced up by a sea. This device, after several essays at a proper term, is now known as the sponson.[2] In some cases on coast routes, instead of a closed shield open slatting was resorted to.

In the year 1837 the first propeller steamer was introduced. In 1838 Phineas Bennett designed, patented and introduced in the steamboat *Novelty*, plying on the Hudson river, a vertical cylindrical boiler in which a hermetically closed furnace was supplied with air by a pump, and all the gaseous products of combustion of the fuel were driven into the steam room of the boiler; the object of this design was to increase the generation of steam and reduce the proportionate area of heating surface.[3] The boiler was removed after a short period of service.

Soon afterward Phineas Bennett introduced the design into a vessel built to ply between New York and Liverpool, under the conditions with her builder that if the design proved to be acceptably successful he was to be paid for the entire plant of engines and boilers and his services, but if not successful he was to remove the entire plant, and at his own expense, without any remuneration whatever. The engines and boilers were completed and operated, but they were not paid for by the builder of the vessel, and the boilers were soon after removed and replaced with others. In consequence of the ashes borne into the valve chests and cylinders, and the evaporation of the oil of lubrication by the heat of the steam, the valves were rapidly worn, and the cylinder pistons shrieked to a degree that would have rendered the design very objectionable, even if it had been successful in other points.

Captain John Ericsson arrived in New York in this year, and in 1842 he designed and directed the construction of the engines and propellor for the United States auxiliary bark-rigged steamer *Princeton*.

In the year 1839 anthracite coal was introduced in the furnaces of the steamboat *North America*, plying on the Hudson river between New York and Albany, and to aid its combustion when a high pressure of steam was required a fan blower, driven by a belt from the wheel shaft, was first resorted to, but soon afterward a small independent engine was used, connected by a belt to the blower.

Anthracite coal was soon afterward first burned without auxiliary draft in the open furnace of a steam boiler.

In the year 1840 wrought-iron shafts were first made, the construction varying wholly from that of the present period; thus, iron bars from 2.5 in. to 3 in. square and of the greatest obtainable length were laid up with a square section, the abutting ends breaking joints with the other bars; hence, the solidity of a section of the mass was subjected only to any imperfection arising from their ends not being wholly welded, by the percentage of the section of one bar to the whole number; and of all the shafts made up to the period included in this paper, only one was broken, and that in conse-

[2] This term was given also by the writer.

[3] Witnessed by the writer.

quence of its being insufficient in diameter for the stress to which it was subjected. This result was foretold when the diameter of the shaft was reduced from that given in the specifications.

The first steam frigates for the United States were constructed in 1842.

Captain John Ericsson applied a surface condenser to the engine of a revenue cutter in the year 1846, and in 1848 Pierson designed an improvement of it, which was further improved by Chief Engineer William Sewell of the United States Navy, and the perfected instrument is now in general, if not in universal, use.

The *Atlantic* and *Pacific*, of the New York and Liverpool SS. Company, "Collins Line," were constructed in the year 1848, and in July, 1850, the *Atlantic* made the then quickest passage between New York and Liverpool, it having taken but ten days and fifteen hours, The *Arctic* and *Baltic* of the same line were launched in the same year.

HORSE POWER—1850.

It was wholly impracticable to obtain the consumption of fuel per indicated horse power in early steam engineering, as engines were not fitted with counters or indicators, and the wood was not weighed. In 1840, with auxiliary or blower draft, and in the absence of counters and indicators, it was computed by weighing the coal consumed, and held to be about 5 lbs., and the speed of the river boats from 8 1-2 statute miles in 1816 increased to 19 miles.

The Clyde line steamship *Pawnee*, Captain A. D. Ingham, took fire at sea and was abandoned off Currituck, North Carolina, at an early hour in the morning of June 26. The vessel was bound from Brunswick, Ga., to Boston, and carried a cargo chiefly of lumber. The steamer *George W. Clyde* of the same line came up and took off the crew and Captain of the burning vessel. The *Pawnee* was a wooden, single screw vessel, measuring: Length, 203 ft.; beam, 38 ft., and tonnage, 1,300 tons. She was built in 1890 at Philadelphia, Pa.

In a recent issue *The New York Maritime Register* announces the thirtieth anniversary of its birth, and we take this opportunity to express a wish that it may enjoy "many happy returns." The value of such a publication to the maritime and merchant interests of the country is enormous, and the task of compilation equally great. But the management is progressive, and, not satisfied with taking the foremost position as an American Shipping Index, announces that the intention is to place the paper at the head of its class throughout the world. To this end an addition has been made to the store of information contained in each issue, so that a list of vessels is given, "no matter in what trade or in what part of the globe they may be engaged, that are available for chartering, or for the reshipment of goods, thus ignoring of the world's fleet only foreign coastwise craft." This adds to the previous regular lists not less than two thousand vessels additional. The paper is sold by subscription, and among those who find it indispensable are Merchants, Exporters, Manufacturers, Banks, Editors, Diplomats and Statesmen. The office of publication is 63 William street, New York.

AMERICAN SCHOOLS OF MARINE ENGINEERING AND NAVAL ARCHITECTURE.

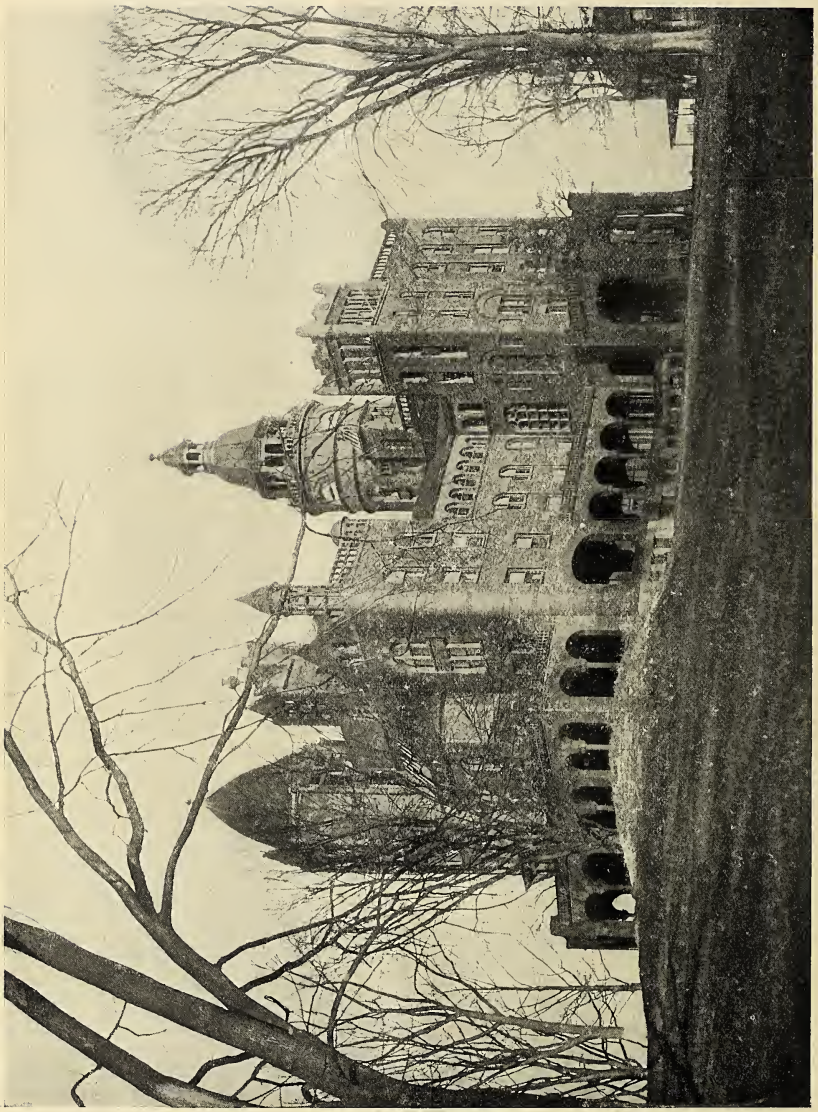
WEBB'S ACADEMY OF NAVAL ARCHITECTURE AND MARINE ENGINEERING, FORDHAM HEIGHTS, N. Y.

Founded by William H. Webb, Shipbuilder, for the Free and Gratuitous Education of Students—Provision also made for the Board, Lodging and Necessary Expenses of Students while in Attendance.

Situated at an elevation of about one hundred and fifty feet above the Harlem river, Webb's Academy of Naval Architecture and Marine Engineering is a conspicuous object in that section of upper New York. The architecturally handsome building is, indeed, a monument to the industry and philanthropy of its founder, William H. Webb, now advanced in years, but in his prime the foremost shipbuilder in the country. The history of this institution is part of the life history of its founder, so that a brief sketch of his career is necessary to clearly convey the purpose of the foundation.

William H. Webb was born in New York, June 19, 1816, his parents having moved from Southern Connecticut, where for many generations the family had resided. In early childhood William H. Webb manifested a liking for ships and ship construction, for instead of joining his playmates in youthful games, he passed his play-hours in boat-building and sailing. He received a good English education, which was completed at Columbia Grammar School, and in his studies he was especially proficient in mathematics. When he came to a choice of a career his father sought to dissuade him from learning the art of shipbuilding, on account of the boy's health, for he was then apparently not robust. No argument, however, could induce the son to take up any other profession, and he was apprenticed in his father's shipyard at the age of fifteen. From that time until the day of his retirement from active business life he was a diligent student and a faithful, energetic worker in the cause of the science and art of shipbuilding. The death of his father promoted him to a share in the business of the firm, and subsequently to the entire ownership.

The younger generation in American shipping circles is not personally familiar with Mr. Webb's work, but older men will recollect the series of triumphs that his skill as a naval architect won, not only for his yard, but for the country. Every class of vessel was turned out, and in warships especially the output was equal, and in many respects superior, to anything afloat. Ships were built not only for this side of the Atlantic, but for European nations. For example, the *Re d'Italia*, built for the Italian government, was the first iron-clad to cross the Atlantic, and was famous for her remarkable seagoing qualities and, then, extraordinary speed. The *Dunderberg*, built under contract for the United States, but eventually sold to France and re-christened *Rochambeau*, is considered the most remarkable production of the Webb yard. Though built thirty-five years ago, she embodied many



WEBB'S ACADEMY OF NAVAL ARCHITECTURE AND MARINE ENGINEERING, FORDHAM HEIGHTS, NEW YORK CITY.

A Corner in the Museum.

Model of Warship Dunderberg.
In the Students' Dining Room.

Ship's Models in the Museum

INTERIOR VIEWS IN WEBB'S ACADEMY, FORDHAM HEIGHTS, N. Y.

ideas which have been put forward as new in modern days. Her model, shown in the illustration on page 11, gives an idea of the advanced style of construction, when compared with conventional warship practice of the period. Her dimensions were: Length 378 ft., beam 68 ft., depth of hold 22 ft., and displacement 7,000 tons. When armed and ready to fight she had a sea speed of 15 3-10 knots, which at the time created a sensation, and which, indeed, is about equal to the sea speed of our modern battleships in commission.

Concurrently with his professional work Mr. Webb took a real interest in many public affairs, and gave much attention to the educational problem. Recollecting the difficulties he had encountered in acquiring a knowledge of the science of his profession, he determined to found an institution where Naval Architecture and Marine Engineering would be taught to deserving students without any cost to them. About ten years ago his ideas found practical expression in the incorporation of Webb's Academy and Home for Shipbuilders, which was accomplished on April 2, 1889. This was with the approval of the then Governor, David B. Hill, and the limit of value of the property to be held by the corporation was fixed at ten million dollars.

The site finally selected by Mr. Webb for the founding of the Academy and Home is located at Fordham Heights, New York City, on the easterly bank of the Harlem river, just north of the University of New York, and contains about fourteen acres, upon which are numerous large shade trees and extensive lawns. Situated at an elevation of one hundred and fifty feet above the level of the Harlem, the grounds command an excellent view of the picturesque surrounding country.

Work upon the construction of the building was begun in 1890, and was completed in February, 1894. It is built of yellow pressed brick, with brown-stone trimmings. The greater part of the structure is five stories in height, with two additional stories on that portion occupied by the Academy. Around the southern end and part of the east and west sides of the building there extends a very wide veranda, while each end of the building is marked by a very high tower. Half hidden as it is by the surrounding grove of trees, its architectural beauty is not realized until one has entered the grounds. The cost of the building and its furnishings, together with the grounds, reached nearly half a million dollars. The proper maintenance of the institution has been amply provided for by Mr. Webb by the deeding to the corporation of very valuable property situated both in New York city and elsewhere.

The dedicatory exercises were held in May, 1894, at which time the property was formally presented to the Trustees. At present the Board of Trustees is composed of William H. Webb, president; Stevenson Taylor, vice-president and general manager; Stephen M. Wright, secretary and treasurer; Andrew Reed, resident manager; together with Thomas F. Rowland, Charles H. Cramp, Henry Steer, George Rowland, William H. Fletcher, Thomas S. Marvel, James O. Poillon, Herbert Lawrence, and Lewis Nixon, and Alexander E. Orr, representing the Chamber of Commerce; Warren A. Conover, the General Society of Mechanics and Tradesmen; Prof. Frederick R. Hutton, Columbia College; and Sheppard Gandy, the New York Hospital.

As its name would indicate, the institution provides a home for aged, indigent or infirm men who have been engaged in building hulls of vessels or marine engines for such, together with the wives or widows of such persons; and an Academy to "furnish to any young man, a native or citizen of the United States, who may upon examination prove himself competent, of good character and worthy, free and gratuitous education in the art, science and profession of shipbuilding and marine engine-building, both theoretical and practical, together with board, lodging, and necessary implements and materials while obtaining such education."

The ground floor of the building contains a spacious hall and broad stairway, reception-room, parlor, a suite of rooms each for the matron and housekeeper, an office for the resident manager, and an extensive dining-room. The floor above is devoted wholly to sleeping-rooms, with the exception of a reading-room and library, which has about fifteen hundred volumes, including both scientific works and fiction. On the third floor are more sleeping-rooms and the well-filled museum. It is here the visitor finds much of interest in the models of different craft built by Mr. Webb, varying from the little harbor tug to the powerful ram *Dunderberg*. Here the student of naval architecture notes the changes that have gradually taken place in the general construction of vessels during the last sixty years. Attention is also drawn to the large number of paintings and engravings illustrative of vessels, varying in type from the ancient galley to the modern warship. Sleeping-rooms occupy the whole of the fourth floor. Then come two of the drawing-rooms, the instructor's office, the mould loft and the workshop. The sixth floor has another large drawing-room and a lecture-room, while on the floors above the latter are the physical laboratory and gymnasium. There is a dark room for the development of photographs, and upon the roof a special arrangement for taking blue prints of the largest size.

The first examination of applicants for admission was held in January, 1894, at which time eight students were admitted, and in May following two more. Since then examinations for entrance have been held but once a year.

Candidates for admission must be between fifteen and twenty years of age, and their application must be made to the President of the Academy not later than the first day of September of the year in which the applicant expects to enter. Owing to the limited accommodations for students and the ever-increasing number of those applying, it has been found necessary to subject all candidates to a very rigid competitive examination in the subjects required for admission, which at present embrace the common English branches, together with algebra up to and including quadratic equations, geometry, both plane and solid, and plane and analytical trigonometry. These examinations are held annually on the Wednesday, Thursday and Friday next preceding the third Monday in September.

Of the students thus far received into the Academy, a large majority have come either from the vicinity of New York or from those States bordering upon the Great Lakes. During the history of the school the

following States have been represented by students: Maine, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Georgia, Ohio, Indiana, Iowa, Michigan and Minnesota.

The academic year begins in the second week in September and extends until the second week in June, with a short vacation at the Christmas holidays and at Easter.

Examinations are held at frequent intervals throughout the year, and students who fail to maintain the required standard of scholarship are summarily dismissed.

During the academic year all students must live in the Academy, but the privilege of spending Sundays at home is generally granted to those whose homes are in the city or nearby towns, providing their work has been satisfactory.

Promptness and regularity at meals are strictly insisted upon. The good health of the students is in no small degree due to this fact. In sickness they receive the care of one or more of eight physicians who render gratuitous service to the institution. In case of severe illness they may be removed to the hospital with which the Academy is provided. But one death has occurred among the students, and that was due to quick consumption.

Students have until ten o'clock at night to prepare for the succeeding day's work, and at that hour all lights must be extinguished. The work of the day is divided, according to the old-fashioned way, into two sessions from 9 to 12 o'clock in the morning, and from 1 to 4 o'clock in the afternoon. No sessions are held on Saturdays, but most of the students during the morning avail themselves of the opportunity of doing original or advanced work.

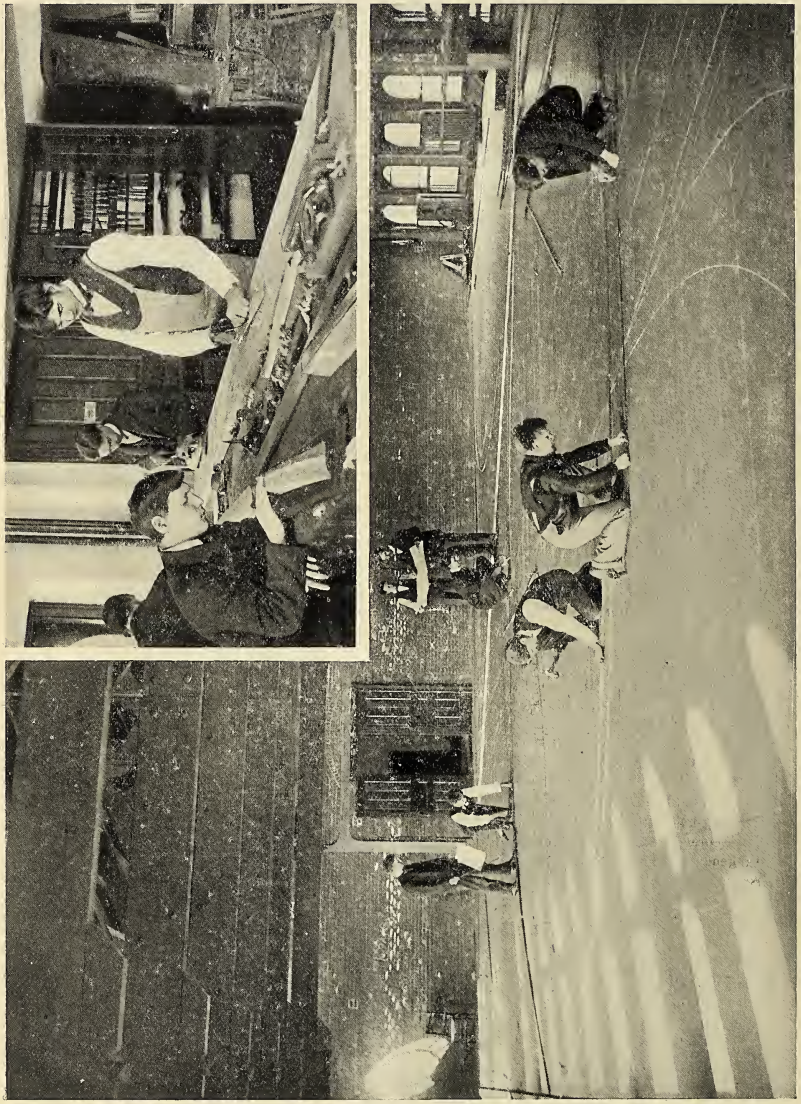
The faculty is composed of Prof. J. Irvin Chaffee, A.M., in the department of Mathematics, who has had an experience of seventeen years in educational work; Prof. Alexander J. Maclean in the department of Naval Architecture, who has been connected for twenty-two years with shipyards in England and the United States; and in the department of Marine Engineering Prof. Wm. Ledyard Cathcart, with an experience of eighteen years as an educator in the United States navy.

The course of studies extends over a period of three years, and is as follows: In Mathematics a course in Advanced Algebra is given in which are especially considered variables and limits series, continued fractions, the binominal theorem, determinants, theory of equations, and the general solution of equations; a supplemental course in Trigonometry covering the solution of trigonometrical equations; Descriptive Geometry with reference to the intersection of planes, curved and warped surfaces; Analytic Geometry covering (a) plane geometry as applied to loci and their equations, the straight line, the circle, different systems of co-ordinates, the parabola, the ellipse, the hyperbola, loci of the second order and higher plane curves, (b) solid geometry involving the point, the plane, the straight line and surfaces of revolution; the Calculus as a means for finding the quadrature of surfaces, the cubature of volumes, the center of gravity and the moment of inertia of different areas and volumes; in Hydrostatics pressures on surfaces are found, centers of pressure, resultant horizontal and vertical pressures, equilibrium of a floating body, stability and metacenter with special problems upon the same; Mechanics with special reference to rectilinear and periodic motion, curvilinear and rotary motion and projectiles; Strength of Materials with an exhaustive treatment of cantilever and simple beams, compression of columns, torsion of shafts, apparent stresses and true stresses and stresses in guns.

The course in Marine Engineering begins with a general investigation of modern marine engines, boilers and auxiliary machinery; of the conditions under which they work in practice; and of the subjects of fuels, combustion and evaporative efficiency. The indicator and its diagrams are studied, and, when opportunity is afforded, students make short passages on coast-wise steamers for indicator practice and the observation of marine machinery under weigh. A considerable amount of time is given during the first year to Mechanical Drawing and Tracing, the models for the latter being selected from the large collection of prints of marine engines which forms a part of the equipment of this department. The instruction in drawing is continued, through the reproduction in finished drawings of sketches with dimensions, to the preparations of original designs of engine details. The Valve-Gears used in marine practice are investigated and laid down. The subject of Heat is studied, and that of the Theory of the Steam Engine follows. The design, construction and operation of Marine Steam Boilers, and the design and drawing of various types of the Screw Propeller, are subjects on which stress is laid. The design of, and working drawings for, propelling machinery for vessels is begun in the second year and is pursued until the end of the course, including all important parts from the cylinder to the propeller. Students who make a specialty of Marine Engineering pass the vacation period in the machine shops of ship-yards or in the engine-rooms of sea-going vessels.

In Naval Architecture the course embraces both the theoretical and practical. The student is first required to make the calculations of areas and volumes to different water lines for a given vessel, then to get out a Displacement Sheet and the Tons per Inch Curve, the Area of Midship Section, together with its co-efficients, is found; the Center of Buoyancy, its position vertically for change of draught, and the longitudinal position of Center of Buoyancy are discussed and their loci found; Trim, Centers of Effort and Pressures, Tonnage, Freeboard and Surplus Buoyancy are treated; a vessel's Stability is considered, while calculations for and construction of curves of the same are made; Curves of Buoyancy, loads, sheering force and Bending Moments of different classes of vessels floating in still water are gotten out; the formula $\frac{p}{y} = \frac{M}{I}$ as applied to the ship as a girder is investigated; the Stability of different types of vessels under peculiar conditions. Resistance at surface and deeply submerged are inquired into; Stress on upper edge of sheer strake when vessel is inclined, and Stresses on the structure of the hull for different conditions of lading are investigated, followed by calculations especially required for Launching Diagrams.

The work in practical Naval Architecture is laid out along lines parallel to the theoretical, and consists of work in the drawing-room, mould loft and shipyards.



STUDENTS OF WEBB'S ACADEMY AT WORK IN THE MOULD LOFT AND IN THE WOOD WORKING SHOP.

Naval Architecture Draughting Room.

Marine Engineering Draughting Room.

Recitation Room of Class in Mathematics.

CLASS ROOMS IN WEBB'S ACADEMY, FORDHAM HEIGHTS, N. Y.

In the drawing-rooms the students familiarize themselves with the proper use of drawing instruments, planimeter, etc., make tracings of detail drawings, derive and plot the several curves mentioned under theoretical Naval Architecture; compare the scantlings of a given steel steamer with the different insurance societies' rules, prepare a sheer draught, and make a half model of the same. The different methods of preparation and assembly of the various parts of a ship in proper order, preparing slip, laying blocks, different ways of bending and setting frames, floors and beams, the laying and fitting of various kinds of keels, stern and rudder frames, construction of bulkheads, pillaring, hatches, bridges, etc., etc., are in turn considered and drawings of the same are made.

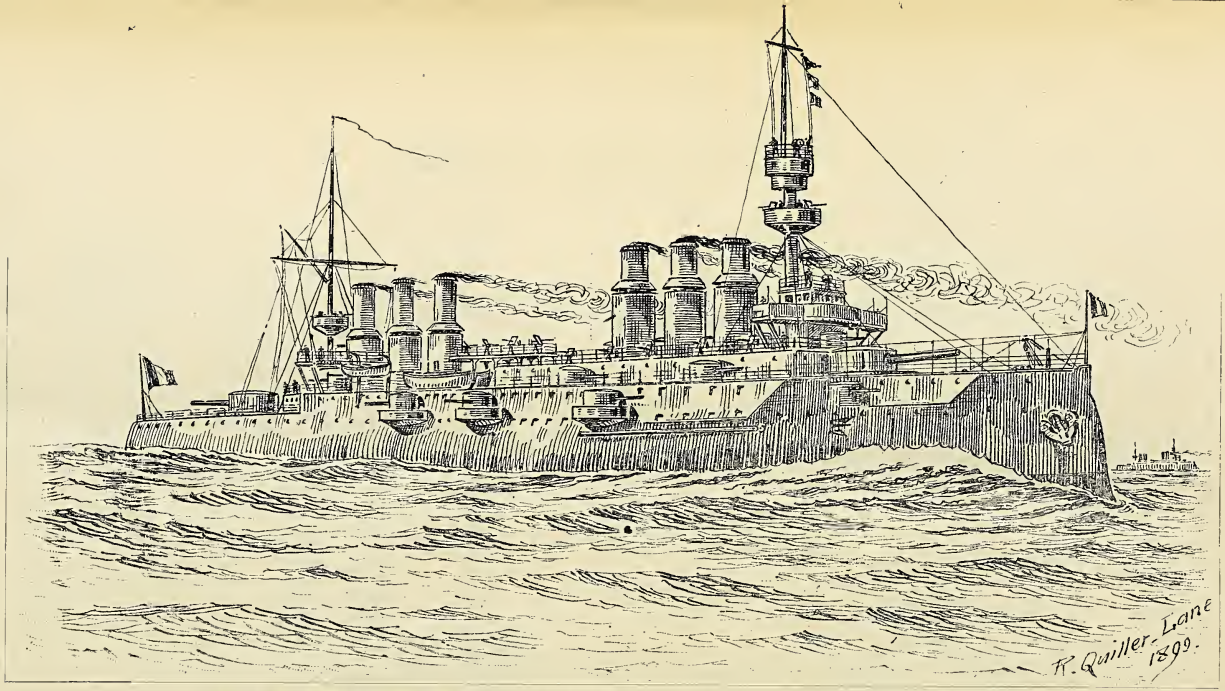
In the mould loft a wooden ship is first laid down and faired up, and moulds of the several parts actually made. This work is followed by the laying down of a cargo steamer, the working drawings of which have already been made in the drawing-room, and the preparation of the scrive board and moulds. A half model of this steamer is then made and lined off completely. Owing to the ample floor space of the mould loft much of the work can be laid out in full size.

Outside of their regular required work, students not infrequently devote their time to the making of beautifully-finished models, with which they decorate the walls of their rooms. Some even go so far as to actually build the craft corresponding to the model and design which they have made. A boat of the "skimming-dish" type was recently constructed by one of the students for use in shallow waters. The yacht *Corsair*, designed and built by members of the classes of '97 and '98, gives an idea of the ability of the students for such work. The *Corsair* was sufficiently large to furnish sleeping accommodations for six persons. After completion she was launched into the Harlem river, and thence passed through the ship canal into the Hudson river. Via this river, the Erie Canal and the Great Lakes the six students made the voyage to their homes at the close of the school year, and so successful and enjoyable did the trip prove that they returned by the same route in the autumn to resume their studies at the Academy.

In order that students may acquire a more extended knowledge of practical Naval Architecture and Marine Engineering than it is possible for them to secure at the Academy, all undergraduates must pass about eight weeks of the summer vacation at work in various shipyards throughout the country. While thus engaged they receive wages commensurate with the services rendered, and in many instances they are offered permanent employment; but they always return to complete their course at the Academy. Those students of the graduating class who wish to enter the employment of the Government are allowed to take the Civil Service examinations, which are held usually a month or two prior to the final examinations at the Academy. Every student who has taken these examinations has passed them successfully and received his appointment shortly after, and in some cases even before graduation. With the exception of one, whose eyes failed him, every graduate from this institution is either in the employ of the Government or engaged at some private shipyard. One is located on the Pacific, and all the others on the Atlantic coast.

The fact that the demand for graduates from Webb's Academy is far in excess of the supply shows the reputation which the institution has already acquired, and vindicates the judgment of the founder.

STUDENTS OF THE MANLY ART—A FRIENDLY BOUT AT WEBB'S ACADEMY.

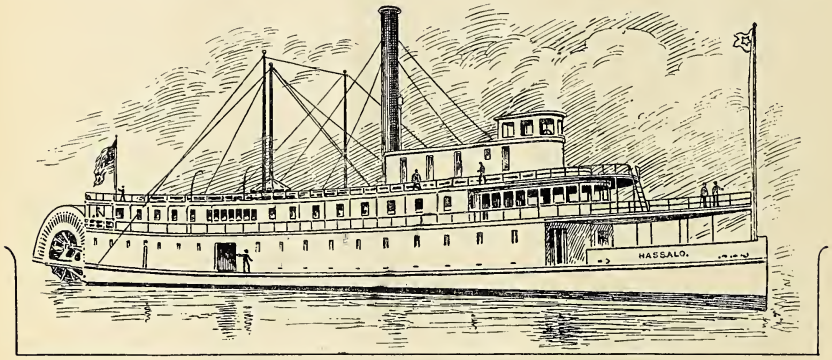


FRENCH TRIPLE-SCREW COMMERCE DESTROYER JEANNE D'ARC BUILDING AT TOULON—TO STEAM AT THE RATE OF 23 KNOTS.

So many vessels of the French Navy are in appearance what may be termed "freaks" that, to those familiar with the practice of that nation, the illustration of the new cruiser *Jeanne D'Arc* will seem "perfectly natural." The ship, launched at Toulon last month, is designed to be a veritable terror of the seas, to be turned loose on the commerce of any hostile nation in time of war. Her dimensions are: Length, 475 ft. 8 in.; beam, 63 ft.; draught, 26 ft. 8 in., and displacement, 11,270 tons. She is a triple screw vessel, with triple expansion engines of 28,500 horse power, with forced draft, and she will have a radius of action of 13,500 miles at ten knots and 1,200 miles at twenty-three knots. Her coal capacity will be between 1,400 and 2,100 tons, as occasion requires, and this will be supplemented by large tank space for liquid fuel. For producing steam forty-eight Du Temple water-tube boilers have been figured on, though some other type may be used. The *Jeanne D'Arc* is rather heavily armored, having a continuous belt at the water line 5.9 in. thick, and above this 3 in. armor plate, and she has also a 2 in. protective deck. Her powers of offense are provided for by two 7.6 in. breech loaders and fourteen 5.5 in. rapid firers and sixteen 3-pounders and eight 1-pounders. The construction of this vessel has caused a certain amount of uneasiness in British naval circles, though why this should be so, in view of the large number of tremendously powerful ships of the type possessed by the British, is not apparent. The steam trials of this new ship, when she is completed, will be watched with widespread interest for political as well as engineering reasons.

RECORD-BREAKING STERN-WHEEL STEAMER HASSALO FOR COLUMBIA RIVER.

The speed record for a stern-wheel steamer is claimed for the new river steamer *Hassalo* built at Portland, Ore., for the Oregon Railroad & Navigation Co. This is a remarkable vessel in many respects, combining as she does the conventional type of stern-wheel river steamer with the most modern methods in her equipment and in construction in her machinery department.



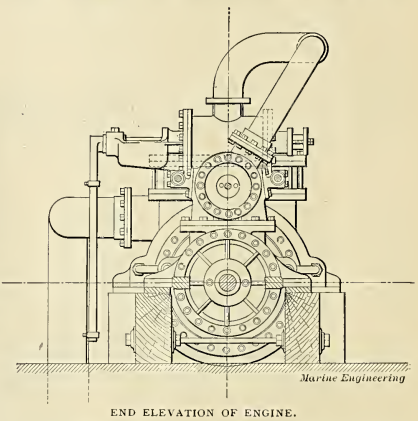
SKETCH OF THE STEAMER HASSALO FOR COLUMBIA RIVER NAVIGATION.

The hull of the vessel is wood, and was designed by Master Builder Carstens, of the O. R. & N. Co., and the machinery was built from the designs, and under the direction, of John A. Lesourd by the Willamet Iron Works of Portland.

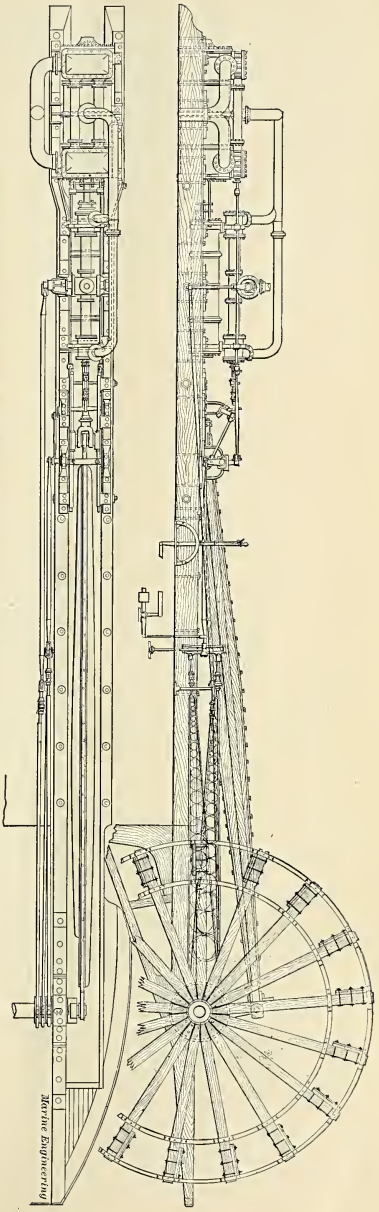
Mr. Lesourd, chief engineer of the works, had often vainly tried to induce the owner of a proposed vessel to use more improved forms of machinery than those commonly in use, but he was unable to go forward until the order for the *Hassalo* was placed. A. L. Mohler, president of the Oregon Railroad and Navigation Co. with a commendable progressiveness, agreed to the innovations proposed, and the result is the most up-to-date stern-wheeler in the country.

In dimensions the *Hassalo* measures: Length 186 ft., beam 30 ft., depth of hold 8 ft., load draught 5 1-2 ft. Her stern wheel is 24 ft. dia., and the buckets are 14 ft. long and 2 ft. wide. Her compound engines indicate about 3,000 horse power. On a trial run on the Willamet river, in dead water, with 150 lbs. boiler pressure the vessel attained a speed close to 21 miles an hour, and in the Columbia river she showed a speed in excess of 26 miles an hour on a two mile run. The steam pressure at the engines was then considerably below the maximum of 185 lbs. per sq. in allowed by the U. S. Inspectors, and a good deal of water was coming over. It was expected that when the steamer is in trim for regular running that she will make the 100 mile trip from Portland to Astoria, on the Columbia river, within four hours. The accompanying sketch gives a good general idea of the style of the vessel as she sits in the water.

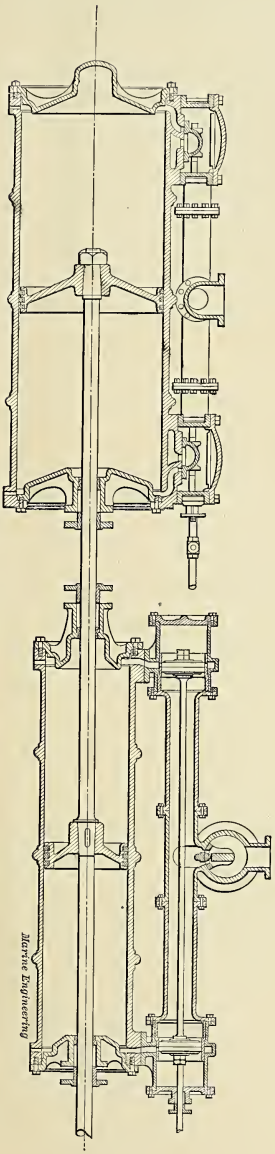
Through the courtesy of the owners and constructing engineers we are also enabled to publish, here, drawings of the engines and boiler of the *Hassalo*. The engines are of the familiar horizontal type used in stern-wheel steamers, but are a decided step in advance of the ordinary practice in that they are compound tandem. The two engines, one on each side of the boat, are alike, and each has high pressure cylinder 22 1-2 in. dia., low pressure 38 3-4 in. dia. and a stroke of 8 ft. At the designed revolutions, 30 per minute, the piston speed is 480 ft. The exhaust, which is led direct into the stack, is intended to be about 5 lbs. above atmospheric pressure, as occasion may require, so as to force the fire sufficiently. In detail the engines are quite modern, having, for instance, dished pistons, and the best of materials have been used throughout. Piston valves are used on the high pressure cylinders, and slide valves on the low pressure. They are operated by eccentric rods, links and radius rods in the usual way, the last named actu-



END ELEVATION OF ENGINE.



COMPOUND TANDEM STERN WHEEL ENGINE FOR OREGON RAILROAD AND NAVIGATION CO.'S STEAMER HASSALO—PLAN AND ELEVATION.

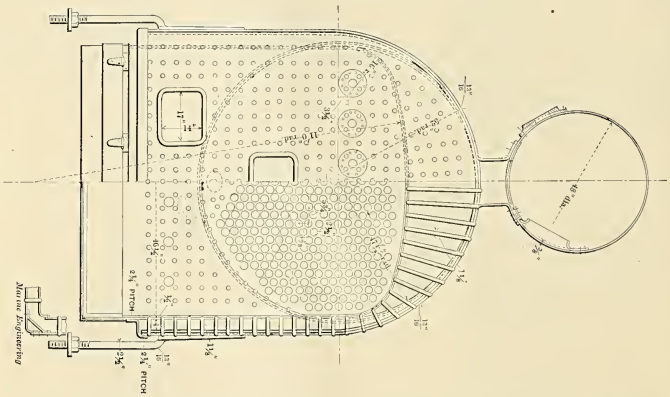


SECTION THROUGH CYLINDERS OF COMPOUND TANDEM STERN WHEEL ENGINE FOR STEAMER HASSALO.

ating rock shaft directly connected to the valve rods and stems. The cut-offs are operated by independent eccentrics in connection with a dropping arm, and the distribution of steam is effected by giving more or less travel to the valves, which is accomplished by raising or lowering the radius rod.

One man handles the engines, the reversing gear of the two sides being connected by a single lever, and a similar arrangement is provided for the cut-offs. The oiling is also chiefly done by the engineer on watch from a special oiling device or lubricator.

The boiler, as shown in the working drawing herewith, is of the locomotive type, and is designed to carry 187 lbs. of steam pressure per sq. in. in accordance with the U. S. rules. The shell is 3-4 in. thick, and is made of 60,000 lbs. carbon steel. It is 96 in. dia., and the length between the tube sheets is 16 ft. There are 462 tubes 2 1-2 in. dia. At the firebox ends they are provided with copper ferrules and the tubes are beaded over in the usual manner, thus forming a very substantial and tight joint. The fire-



box is 94 in. wide, 92 in. deep to the grate bars and 11 ft. long—all inside measurements. Water spaces at the sides are 4 in. and at the back 5 in. Inside of the firebox there are six tubes 3 in. dia. reaching from near the bottom of the after end of the firebox, in an inclined position, to near the top of the front. They support specially made firebricks, acting as a baffle plate and protecting the tube sheet from the blow pipe effect of the flame, and also serving to distribute the heat more evenly. Shaking grates are used, and, as they are thus kept free from choking, cinders present no difficulty. Ashes and cinders are disposed of by a steam exhauster placed at the after end of the firebox, and connected to a hopper, in which they are raked when it is desired to throw them overboard.

To insure dry steam, a steam dome 48 in. dia. and 12 ft. long is placed on top of the boiler and attached by two welded steel nozzles securely riveted to both drum and shell. Live steam is carried direct from the dome through a stop valve, to the throttle in the engine room and thence to the two engines. The smoke stack is 52 in. dia. and 61 ft. high. Three duplex pumps are used for boiler feed and for the general steamer service and two handpumps, additional, are fitted.

Steering is effected by a steam gear having a steam cylinder and an oil controlling cylinder, the connections being made directly to the pilot house. A very complete electric lighting plant is also provided.

Passenger accommodation in the steamer is very luxurious; carpets, furnishings, paintings and decorations are made to harmonize in excellent taste, and the dining room is arranged so that those of the passengers who desire can use small tables, and thus enjoy a reasonable amount of privacy. Much care has been expended also upon the equipment and service in both pantry and kitchen, and experience has not been spared nor money stinted to make the vessel an up-to-date floating hotel. When put on her regular service the *Hassalo* will become, undoubtedly, one of the most popular river steamers on the Pacific coast.

Torpedo-Boat Destroyers.—In our issue of March, 1899, we published a description, with engravings, of one of the torpedo-boat destroyers built for the Imperial Chinese Government by F. Schichau, of Elbing, Prussia. The four boats built attained rates of speed of from 35 to 37 knots in the open sea. The seagoing qualities of the boats have been very thoroughly tested on the voyage out to China, whither they were sent under their own steam. They started from Elbing, and by way of the Baltic, German Ocean, and Bay of Biscay reached Gibraltar, and thence through the Mediterranean Sea steamed to Port Said, and from there through the Suez Canal they steamed direct for Colombo, Ceylon, without touching at the port of Aden. At latest reports they had reachel Colombo, in first-class condition, having made the run of 3,500 knots without stopping. They had also a considerable quantity of coal left in the bunkers, thus demonstrating their ability to make a longer "continuous steaming" trip if necessary. Machinery repairs were practically nil.

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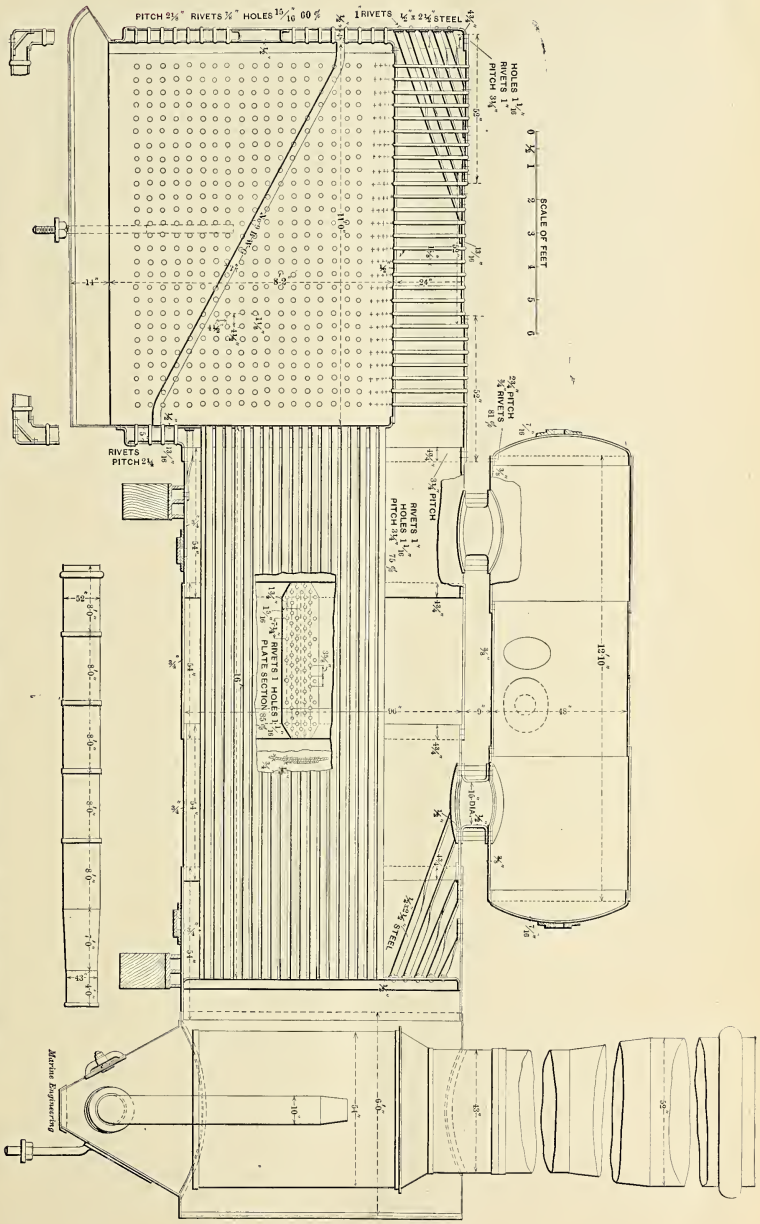


LOCOMOTIVE TYPE BOILER FOR COLUMBIA RIVER STERN WHEEL STEAMER HASSALO BUILT BY WILLAMET IRON WORKS, PORTLAND, ORE.

CONSIDERATION OF THE INDICATOR AND ITS USES ON BOARD SHIP—V.*

BY R. W. JACK.

It may appear from the somewhat lengthy calculations herewith presented that this method involves a greater amount of mathematical knowledge than the majority of our brethren possess, but it should be remembered that there is nothing really worth its possession in the view of scientific attainment which does not involve a certain exercise of the mental faculties. An interesting study crowned with success is one of the highest pleasures of the most distinctive and permanent attributes of man. But in the calculations we have made there is nothing actually required beyond a conception of the simple rules of arithmetic, and they have been worked out more in the hope that the detailed statement of principles would be better appreciated than a mere tabulated presentation of results.

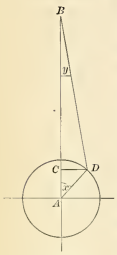


FIG. 12.

The graphic method of representing forces, velocities, distances, times, etc., and their combinations, appeals more forcibly to the understanding, and is of great assistance to a more ready perception of the applicability of mathematically demonstrable facts. The subject which we have been considering, like most others in recent teaching, is easily illustrated by curves, and we will now proceed to show, first, how a curve of velocities may be plotted out, and next, from such a diagram of velocities, how a curve of their differences may be traced which shall also represent the forces at work either in effecting an acceleration or retardation of the piston and reciprocating mechanism of an engine. Describe a circle (Fig. 13) *A, D, B, E*, with a radius equal to the length of the crank, and from *B*, with a length of connecting rod mark off *B F* on the center line of engine. Divide the semicircle *B, D, A* into any number of parts, say, 10 (preferably equal parts), and from each of those points on the circumference 1, 2, 3, etc., with the length of connecting rod mark the center line

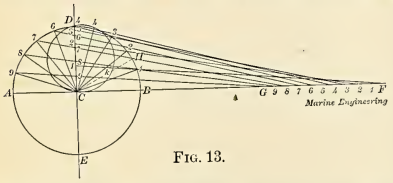


FIG. 13.

also at 1, 2, 3, etc. The latter points show the positions of the piston between the two points *G* and *F* when the crank occupies the positions shown by the corresponding numerals. From the points 1, 2, 3, etc., on the line *G F*, and through the same points on the circumference, cut the line *C D*, which will give the corresponding points, 1, 2, 3, etc. The distances C_1, C_2, C_3, etc., on the line *C D*, will represent the velocity of the piston in relation to the constant velocity of the crank pin represented by the radius *C B*, or length of crank arm. If those distances on the line *C D*, C_1, C_2, C_3, etc., be laid off on the radial lines C_1, C_2, C_3, etc., we obtain points through which a curve may be drawn representing at any position of the crank the velocity of the piston compared with the uniform rotative velocity of the crank pin, as represented by the length of crank arm, *i. e.*, for any intermediate position *C H* of the crank, the velocity of the piston is shown by the distance *Ch*, or that portion of the line *C H* enclosed by the curve of velocities. It may be interesting to observe that the curve here given also represents the value of the rotative effect on the crank pin, and if the pressure on the piston be considered constant throughout the stroke the curve will represent the turning moments on the crank, because, neglecting friction and the weight of the reciprocating parts of the engine the total work performed on the crank pin is equal to that transmitted by the piston. Bearing in mind that velocity is the equivalent of distance in a given time, the forces on piston and crank pin may, therefore, be represented by their relative velocities. But in this case we have supposed the pressure on the piston to be constant, hence this pressure being constant and the velocity of crank pin being constant, the remaining terms—velocity of piston and tangential pressure on crank pin—vary directly as each other. It may just be added that in general $P\ V = Cv$ where P and C are respectively the pressure on piston and crank pin, V and v their velocities.

From the diagram of velocities we may now conveniently trace a curve of their differences. For instance, when the crank is in the position *C B*, Fig. 13, the velocity of piston is zero, at *C*, the velocity is C_1 on the line *C D*. The difference of velocities, or acceleration between those two positions (supposing the acceleration to be constant) is, therefore, equal to C_1 on the line *C D*. Between the positions of crank C_1 and C_2 the difference of velocities is C_2—C_1, on the line *C D*, Between the positions of crank C_2 and C_3 the difference of velocities is C_3—C_2, on *C D*, and so on for every position taken. Again, describe a circle to represent the path of crank pin and divide the diameter *A B* in the same ratio as the distance *G F* (Fig. 13). From the points, 1, 2, 3, etc., Fig. 14, erect perpendiculars equal to the differences of velocities or accelerations shown on the line *C D*, Fig. 13, viz., C_1, C_2—C_1, C_3—C_2, C_4—C_3, etc. A curve drawn through the extremities of those distances will represent at some speed the forces brought into action in accelerating or retarding the speed of the piston, etc. It will be seen that the acceleration varies from a maximum at the beginning of the stroke to the point where it becomes zero, and at this point also the piston has attained its maximum velocity. The retardation of the moving parts begins at *O* and increases to a maximum toward the end of the stroke, as shown.

In modern marine engines, where there is little variation from a generally accepted standard in piston speed, length of stroke and design, the modification of the diagram necessitated by a consideration of the effects of acceleration and retardation is seldom of sufficient importance to seriously interfere with our calculations regarding the strength of the structural details of en-

*From a paper read before the Institution of Engineers and Shipbuilders at Hong Kong.

gine design. In some special instances, where the proportional conditions are not complied with, such as excessive weight, short stroke and high piston speed, it is quite within the teaching on the subject that those abnormal conditions may cause not only inconvenience, but disaster.

There is one other modification necessary in converting the ordinary indicator diagram to one representing pressures on the crank pin of vertical engines, viz., that due to the constant weight of piston, rods, etc., The effect of this simple weight is, as a rule, very slight. It would be shown by an increase in the effective pressure on the down stroke and equal diminution on the up stroke. We would, therefore, shift the back pressure line further from the steam line on the one side, and bring it nearer on the other. For instance, in the case we have had under review the total weights were 1,200 lbs., and diameter of cylinder 17 in., the amount per sq. in. of piston area is therefore

$$\frac{1,200}{17 \times 17 \times .7854} = 5\ 1\text{-}4 \text{ lbs. (nearly).}$$

Turning our attention to those practical considerations which determine the shape or form of an actual indicator diagram, it may be observed that those forms are of an almost endless variety. It should be said that to produce an ideal diagram there are four distinct or critical positions of the valve with respect to the positions of the piston, and the complete figure may be said to consist of six lines, viz., 1st—the steam line, from the beginning till cut-off; 2d—the expansion line, from cut-off till exhaust opens; 3d—the exhaust line, between the terminal pressure of the expanding steam, and back pressure line; 4th—the line of back pressure or full exhaust, between the position of full exhaust and the closing of exhaust ports; 5th—the compression line, between the closing to exhaust and the opening to steam; 6th—the lead line, between the opening to steam and the end of stroke. In actual diagrams it is sometimes difficult to locate with precision the various points and the exact length of the lines. In the case of slow-running engines and with most types of patent valve gears the points may be more distinct and the lines more easily defin-

FIG. 15.

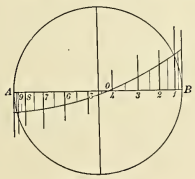


FIG. 14.

able, but as special forms of valve gear are a very small proportion of those actually at work, and because they present no very distinctive advantages over the common link motion in the distribution of steam, we may consider them together. To be able to readily explain the sometimes mysterious figure traced by an indicator, it is absolutely necessary that we should be thoroughly acquainted with the internal condition of the engine, and to the same end it is very desirable that the relative positions of piston and valve at the various points should be exactly ascertained by turning the engines a complete revolution and measuring from fixed points.

The steam line on a diagram taken from a high-pressure engine with ample area of steam pipe and through stop valves should be parallel with the base or atmospheric line. If the diagram be taken at a speed below full power and regulated by the main stop valve, the steam line will show a decreasing pressure toward the point of cut-off, due to the contracted orifice. If, on the other hand, the stop valve be full open and the diagram still shows a falling steam line, then we may conclude that the area of steam ports is insufficient for the speed of the piston, and for the valve gear with which the engine is fitted. It is here that an advantage rests with the advocates of special valve gears and of separate expansion valves. It has been sought to be shown that a loss is occasioned by the wire-drawing of the steam when using the common link motion, and that this loss may be avoided by the adoption of special valve gears giving a quick opening and a quick closing of the slide valve. It is not actually necessary that the slide valve should give a quick opening to steam, because the speed of the piston is so comparatively slow during the first part of the stroke that almost any arrangement of gear will give the requisite opening; but the steam is always more or less wire-drawn with the Stephenson link motion. This tendency is exaggerated exactly as we increase the expansion by cutting off the steam earlier in the stroke; the more steam lap we add to the valve and the further we advance the eccentric, the shorter becomes the arc of the circle which represents the opening to steam. The diagram shown in Fig. 15 will help to make this point clear. In the case of vertical engines *C D* will represent the position of the crank. If the steam be carried the whole length of the stroke, and be from *D* toward *B*, *C B* would represent the center line of the eccentric, and the outside lap of the valve would be nil. The opening to steam would, therefore, take place at *C B* when the valve is moving at its greatest velocity, and the closing would occur at *C A* when the valve has attained its maximum velocity on the return. The valve would be at its lowest extremity, and, therefore, full open on the top when the eccentric is in the position of *C E*, and the piston would have attained its maximum velocity about the position *C B*. By increasing the expansion the angle between the crank and the eccentric is increased, and as the velocity of the valve decreases from *B* to *E*, the nearer we bring the center line of the eccentric toward *E* at the instant of opening or closing to steam, the slower becomes the motion of the valve. Suppose, for example, we wish to cut off steam when the crank is at mid-stroke, that is (disregarding the effect of lead), the slide valve has to remain open during the same interval, viz., one half stroke, or an angle of 90 degrees. When the eccentric is in the position *C E* the valve will be full open to steam on the top side, so that an angle of 45 degrees on either side of *C E* will give the position of the eccentric when the valve is just opening or has just closed. *C F* would, therefore, become the position of the eccentric at the point of opening, and *C G* the posi-

tion at the instant of shutting to steam, thus showing that the earlier we effect the cutting off of the steam the slower will be the motion of the valve at that instant, and the tendency to wire-drawing of the steam consequently aggravated. The question of wire-drawing steam is not quite so simple as it appears, or as it may have been in the days of simple engines. It is really a question of economy between pure steam of a certain pressure and super-heated steam of a lower pressure. It follows that when steam of a certain pressure is allowed to pass through an orifice whose area is insufficient to allow of the full pressure being maintained the steam becomes superheated by the friction of its molecules against the sides of the passage.

Board of Life Saving Appliances.

The Board of Life Saving Appliances for the United States Life Saving Service had a meeting at the Post Office Building in Boston, in May, to consider devices and appliances proposed for use of the service. This board, which is appointed by the Secretary of the Treasury, consists of seven members including:

Professor C. H. Peabody, of the Massachusetts Institute of Technology; Captain C. A. Abby, R.C.S.; Major D. A. Lyle, Inspector of Ordinance, U. S. A.; Lieut. F. A. Levis, R.C.S.; B. C. Sparrow, District Superintendent, L. S. S.; J. G. Kiah, District Superintendent L. S. S.; N. M. Knowles, Asst. District Superintendent, L. S. S.

The meetings of the board were attended by Hon. S. I. Kimball, the General Superintendent of the Life Saving Service.

This board usually meets annually, but as there was no meeting last year an unusually large amount of material had accumulated, requiring a protracted meeting.

Among the subjects presented for the consideration of the board were: Life boats, life rafts, wagons for carrying boats, methods of launching boats, methods of signaling, oil carrying projectiles, the use of reindeer hair for life preservers, holders for flash lights and other similar matters. The devices and methods were presented by written descriptions, by drawings, or by models, and when desired the board gave hearings to those who had subjects for consideration.

It has been conclusively shown by the experiments and experience of the Life Saving Service that life rafts cannot be used from the shore, and that it is dangerous to try to force a life raft out through the surf. Again it has been found that waves which break in shallow water forming a surf are not affected by oil, even though it be used in large quantities; the conditions at sea are entirely different, and oil has long been known to have a good effect in reducing the turbulence of the water. There are methods and devices, however, which are presented by persons who have little or no knowledge of the needs or conditions of the service, and which are clearly not adapted for the use of the service. These are readily disposed of. The utmost care is required in the consideration of subjects that appear to have real merit; on the one hand there is the desire to use all means for improving the chances of saving life, and on the other the knowledge that a real test can be made only in actual service when a failure may lead to loss of life either of the people in peril on wrecks or of the life saving crews who are trying to aid them.

One of the crying needs of the service is for a thoroughly practical wagon for carrying surf boats. Contrary to the usual conception the greater part of wrecks occur not on a "rock bound coast," but on long stretches of desolate beach which in stormy weather are deserted by all except the life saving patrol. The surf boat must then be dragged on a wagon to the scene of the wreck, often to long distances over a rough and trackless country, sometimes by the aid of horses, but often by the crew themselves. The wagon should then be light, strong and simple, and must have wide tires so that loose or soft ground may be crossed with safety. The gauge or width between the wheels must not be excessive, for advantage should be taken of roads or tracks when they exist, and in many places where there is no track a wide wagon may be more difficult to handle. When the boat is brought to the beach opposite the wreck it must be unloaded, in which process under the most favorable conditions there is much lifting and danger that men may be strained and injured. Some improvement there has been in the construction of wagons and in methods of loading and unloading, but much remains to be desired. The service labors under the difficulty that the men who know what is needed are not wagon builders, and so few wagons are needed for the whole service that there is no incentive for competition among wagon builders, while the government requirements that all supplies shall be open to all bidders appears likely to take away from any builder, who may master the problem, the fruits of his labor. It would appear, however, that there should be some wagon builder who would for the good of the service learn the conditions to be met and strive to find a solution of the problem. But the problem is not an easy one, for the ideal boat wagon appears to demand a combination of a light road wagon with a traveling-crane.

A very bright readable weekly has made its appearance in London under the title of *The Skipper*. This is styled, by way of a subtitle, "A Weekly Log of Nautical Matters." No. I opens with an article by E. F. Knight, London *Times* correspondent during the Cuban war, describing how he reached Havana. Then comes a list of the current Admiralty publications, and an article on the growth of the Navy League. Following this in succession are pages devoted to yacht racing, naval matters, aquatic sports, yacht designs, news from various yachting districts, and a good deal of miscellaneous news matter of current happenings in yachting circles. A short story, book notes and letters complete the twenty-four pages of contents, which are well illustrated with half-tones. Altogether the first number is a very creditable one, and if it is an index of the purpose of the publication it will rightly belong to the group of yachting papers. The United States subscription to this paper is 30s. for twelve months and 15s. for six months. The office of publication is Clock House, Arundel street, Strand, London, W. C.

SUGGESTIONS FOR THE SELECTION OF ELECTRIC LIGHTING SETS FOR SHIP USE.

BY ALTON D. ADAMS.

Engines and dynamos for ship lighting should combine qualities of efficiency, light weight and small bulk per unit of capacity, to a high degree. The first cost of plant for ship lighting is secondary to these qualities, as it can be readily shown that the advantages to be gained from each outweigh any possible increase in cost. To consider first the importance of high efficiency in the engines driving dynamos, assume a fair cost of steam from first-class marine boilers to be twelve pounds of coal per one hundred pounds of steam, which, with coal at five dollars per short ton, amounts to three cents. With simple engines taking thirty pounds of steam per horse power hour, the steam for one hundred horse power during a year of three thousand hours amounts to $100 \times 30 \times 3000 \times .03 = 270{,}000$ cents, or two thousand seven hundred dollars.

With a compound engine taking twenty-four pounds of steam per horse power hour, the value of steam per one hundred horse power for three thousand hour year is $100 \times 24 \times 3{,}000 \times .03 = 216{,}000$ cents, or two thousand one hundred and sixty dollars.

The difference between these yearly costs is found by $\$2{,}700.00 - \$2{,}160.00 = \$540.00$, or fully enough to cover the extra price of a compound over a simple engine, by the saving in coal alone, to say nothing of the saving in boiler capacity, labor of firing and the space occupied by the extra coal.

As the size of engines used in ship lighting plants is usually not more than one hundred horse power, and the additional saving of triple expansion over the compound type is small, the compound engine seems best suited for these plants.

There is no such variation in dynamo efficiencies as between the simple and compound engines, but a difference of 5 per cent is not uncommon among the various electrical machines on the market, and the highest efficiencies regularly attainable should be insisted on.

By the efficiency of dynamos is, of course, meant the ratio of the electrical energy delivered from them to outside conductors, divided by the mechanical energy delivered to the armature shaft. Efficiencies given in the following table are the least that should be expected in first-class dynamos at the common speeds of direct connection and on full load:

Kilowatt Capacity...	5.	10.	15.	20.	30.	45.	60.	75.	100
Efficiency.....	.75	.80	85	.88	.89	.90	.91	.91	.92

As the efficiencies of both engines and dynamos are lower at partial loads than at full load, two or more generating sets should be employed in all save the smallest plants, so that each set when in operation may be as nearly as possible at full load. To show the importance of considerations as to weight and bulk, the following table is compiled from the catalogues of several large manufacturers, showing the weights of machines of various capacities as commonly offered.

The weights in each case are for a complete engine and dynamo direct connected on a common bed-plate. This table shows the weights of different sets of the same capacity to vary, in many cases, more than fifty per cent, and this unnecessary weight with its attendant bulk takes just so much from the capacity for freight-paying cargo. Take, for example, a plant of four fifty K. W. generators with engines, which may easily be required on board a large ship for lighting and motive power purposes, as ventilating, hoisting, and mechanical draft. At two hundred pounds per

WEIGHTS OF COMMERCIAL LIGHTING SETS.

Make.	K. W.	Lbs	Lbs. per K. W.	K. W.	Lbs.	Lbs. per K. W.	K. W.	Lbs.	Lbs. per K. W.	K. W.	Lbs.	Lbs per K. W.	K. W.	Lbs.	Lbs. per K. W.
A.....	4	1600	400	15	4700	313	30	8000	266	50	10000	200	75	15500	200
B.....	4	1000	250	15	3000	200	30	6000	200	60	9700	161	80	12600	157
C.....	3	1500	500	15	5800	386	32	9000	281	36	10000	277			

K. W. the weight of this two hundred K. W. generating plant is $200 \times 200 = 40{,}000$ pounds, while at one hundred and sixty pounds per K. W. the weight is $200 \times 160 = 32{,}000$ pounds.

The difference between these weights, or $40{,}000 - 32{,}000 = 8{,}000$ pounds, is obviously worth much more as added freight capacity during the usual life of a ship than any additional cost of the lighter over that of the heavier equipment.

In vessels intended for high speeds, as yachts and express boats, which are usually of small size and do not require an electric equipment of large capacity, the saving in weight by the lighter type of equipment is worthy of consideration for its effect on speed alone.

Suppose, for instance, that only a single set of fifteen K. W. capacity is required, the difference in weight between the lightest and heaviest type for this capacity is $5{,}800 - 3{,}000 = 2{,}800$ pounds; a dead weight which no designer of a boat intended for high speeds can afford to disregard.

It should be noted that weight per unit of output decreases with increased capacity up to a certain point, depending on the particular make of apparatus, so that when the total required capacity is not large a saving in weight may be effected by using the smallest convenient number of units.

Even the smallest weights per unit of capacity given in the table should not be regarded as the best that can be produced in this line. Further improvements are to be expected and can be secured at this time if insisted on by purchasers and engineers.

Up to the present time the engines and dynamos offered for ship lighting have been substantially the same as to weight and bulk as those used on land, except in a very few cases, and have often been the designs regularly sold for land use. In most other branches of ship equipment the necessity for the smallest weights consistent with first class construction has long since been recognized and complied with, and there is certainly ample warrant for special construction in dynamos for ship lighting and their driving engines, in order to reduce the excessive bulk and weight now common in this apparatus.

The main engines of a first-class steam vessel are of quite different construction and much less weight per unit of capacity than those commonly used on land, in spite of the fact that the type of construction in marine engines is somewhat more costly.

A vertical engine with cylinders at the top is best

adapted for dynamo driving on board ship, because of the small weight and bulk possible in this type and also its adaptation to high rotative speeds. The value of high speed of rotation is considerable in the reduction of engine weights, but more so in those of dynamos, and it seems that much is yet to be accomplished in this direction.

A very few makers of vertical engines run sizes above one hundred horse power regularly, at from four hundred to five hundred revolutions per minute, but the great majority cling to speeds not over three hundred and fifty. It seems, however, that the highest of these speeds can be much exceeded, with proper designing in respect to weights of reciprocating parts and other features. Not only does a high rotative speed tend to reduce the weight of engine frame, but also that of fly wheel, since the greater the speed the more frequent are the impulses given the wheel, and for a given diameter the greater the energy contained in its moving mass.

Coming to the question of dynamos, the method of driving by direct connection on a common base with the engine seems much preferable to any other. Something may be saved in weight by belt driving, but the loss of space, convenience and reliability render this method unsuitable for use on board ship. All sorts of flexible couplings between the engine and dynamo should be avoided and a stiff, continuous base with bearing outside of the commutator end of the armature shaft insisted on in every case. Two methods of rigid connection between the armature of dynamo and the engine shaft have been in general use. In one method the armature has its own shaft, which is provided with half of a flange coupling on the end next to the engine; the engine shaft carries the other half of the flange coupling and is joined to the armature shaft with through bolts; the other method of connection is to extend the engine shaft over that part of the base occupied by the dynamo and through the bearing at commutator end of armature, the armature for this construction being built with its commutator on an independent sleeve, which can be put on the engine shaft at will.

The last named arrangement, with continuous engine shaft through all the bearings is obviously stiffer and more certain of alignment, and should be selected in all cases. The means for electric contact at the commutator require more care and attention than all other parts of the dynamo together, and the best practice having settled on the carbon brush for this purpose, nothing else should be accepted. Numerous makes and varieties of carbon brushes will be found, however, and some give vastly more trouble than the copper brushes used in the older practice.

Carbon in any form has a much higher electrical resistance than copper, and the friction of most carbon brushes on commutators is greater than when copper is used; both these conditions tend to produce additional heat at the commutator, and this is one of the most serious troubles the dynamo tender has to avoid. There is much difference in carbon brushes, both as to their electrical resistance and friction on copper commutators, and hard brushes which have a rough feel on their freshly dressed or broken surfaces, also those which have mysterious lubricating compounds pressed or worked into them, should be avoided.

By far the most satisfactory brush for electrical machines is made of pure graphite with a thin coating of copper on the outside, and no oil or grease of any kind mixed in it. Such a brush can be used on a commutator with absolutely no oil or commutator compound applied, and will cause less trouble and wear of the commutator than any other brush.

The several forms of commutator segments are of, either, cast, drawn or drop-forged copper; the drawn and drop-forged kinds are practically the same as to electrical conductivity and wearing qualities, while cast copper is not only inferior in these respects, but has the unfortunate quality of developing blow and sand holes occasionally when segments are partially worn out. It seems strange that with the known inferiority of cast copper, some makers persist in its use, especially in view of the fact that all of the large and better manufacturers have long since adopted the drawn and drop-forged varieties.

Coming now to the general types of dynamos in use for ship lighting, a great variety exists. English ships are, mostly, supplied with dynamos of the bi-polar type of the utmost simplicity, having but one or two magnet coils, easily understood armature winding, comparatively small commutator and but two sets of brushes. Only a few bi-polar dynamos, in the smallest sizes, are offered by American makers for direct connection in ship lighting, the types having four, six, eight and even more poles being in favor with makers on this side of the Atlantic. There is no doubt that with equally good design something is gained in weight by the use of four instead of two poles, and this tendency operates in a less degree with larger numbers of poles up to a certain point. When it is held in mind, however, that each additional pair of poles involves two more magnet coils, two more sets of brushes and some additional complication of armature winding and commutator, it is a question whether the multiplication of parts beyond four-pole machines is warranted in dynamos for ship use. Intelligent design should aim to adapt every device, in some measure, to the conditions of its use, and it seems fairly evident that a machine so little understood by the ordinary mechanic, as a dynamo, may reasonably be spared some complications, when its repair may be necessary at some out of the way port, that would be quite admissible were it intended for office-building lighting in New York.

Sufficient skill to rewind and repair dynamos of the simplest types is now fairly common among mechanics, but any serious trouble with the commutator or windings of an eight or ten pole dynamo would be very apt to wait until the experts of an electrical shop could reach it.

That portion of a dynamo which usually fails first is the insulation which separates the windings from the iron parts. This insulation is in the main of fibrous materials, as cotton cloth and paper, though mica is used at some points. When dynamos are in use the insulation is constantly subject to electric strains and heat, and its ability to withstand the former depends much on the degree attained by the latter.

Cotton cloth and paper deteriorate rapidly under heat of from 400 to 500 degrees F., and to quite an extent from 200 to 400 degrees F., so that it is desirable that the parts of a dynamo shall not become hotter than about 200 degrees F. in regular use. A rise in temperature above surrounding air is commonly allowed for dynamos to be used on land, under continuous run at full load, of from 70 to 90 degrees F., which allows the air to reach 110 to 120 F. before the parts of the dynamo reach 200 degrees F., and this point is seldom exceeded.

On ships, however, engine-rooms usually become hotter than is common on land, and a lower rise in temperature should be provided for in ship dynamos. The United States Navy regulations allow only fifty degrees F. rise in temperature of dynamos under continuous run at full load, and the life of dynamo windings on merchant ships would no doubt be increased by similar requirements.

Recommendations are now heard in some quarters of enclosed dynamos for ship lighting, but while the enclosed features have much value for small electric motors that must be located in exposed, dusty or dirty places, their desirability for large dynamos in ship engine-rooms, where they may be kept dry and clean, is very questionable.

It should be held in mind that if a given dynamo is enclosed in an air-tight case, its capacity to dissipate heat is greatly reduced, so that its higher temperature will do more harm to its insulation than any dirt that may accumulate in a reasonably clean engine-room. If the dynamo case has a number of fine screens, quite a portion of the dirt in the air gets through them, and as the machine in this case is seldom cleaned, it is apt to become dirtier than if entirely open and given a reasonable amount of care. On the other hand, a new machine designed to operate at a low temperature in an air-tight case is certain to be much heavier than one having the parts in which heat is generated exposed.

Durability and simplicity are two points which should be ever present in the design or selection of an electric ship-lighting plant, the care of which, in small vessels at least, will be entrusted to the engineer or oiler on watch, additional to his regular duties; and even in large vessels it is not likely that the engine-room staff will have the same amount of time to devote to the care of the electrical machinery, in running, that would be expended in a shore plant of any magnitude.

Tug Boat Gypsum King.—A very successful builder's trial of this vessel took place June 17 on Long Island Sound. She is a large powerful sea-going vessel built by the Burlee Dry Dock Co., Port Richmond, Staten Island, for the J. B. King Co., of New York, and she will be employed in towing barges between New York and Windsor, Nova Scotia. The new tug is of the following dimensions: Length, 165 ft.; beam, moulded, 29 ft. 4 in.; depth of hold, 19 ft. 3 in. She is fitted with triple expansion engines, with cylinders 17 in., 27 in. and 45 in. dia. and 36 in. stroke, furnished with steam at 175 lbs. pressure by two Scotch boilers 13 ft. dia and 11 ft. long. The barges to be towed will be over 200 ft. in length and each will carry 2,100 tons of gypsum rock on about 17 ft. draught of water.

STEAM PIPES ON VESSELS—MATERIALS USED AND CAUSES OF FAILURES.—I.*

BY J. T. MILTON.

In 1895 the author had the honor of reading a paper on "Steam Pipes" before the members of this institution, and it is thought that some further remarks upon the subject would not be out of place, in view of its increasing importance. When it is remembered that there are in existence about 17,000 steam vessels of above 100 tons register, and that in any vessel the failure of a steam pipe may possibly lead to her total disablement, and that every day sees several additions to the number of vessels in which steam pipes of larger size and working at higher pressure are used, it will be realized that the subject is one which demands the attention and consideration of marine engineers.

When dealing with matters in general use, or coming under common observation, there is no doubt that a few failures teach their lessons more emphatically than a large number of successes; and, therefore, in this paper reference will be made to some of those cases of accidents to steam pipes which have been publicly inquired into under the provisions of the Boiler Explosions Acts of 1882 and 1890. A summary of all the cases which have been so inquired into is given in the appendix to this paper, but it must not be thought that these are all the serious accidents to steam pipes which have happened, as many failures occur which are repaired without the facts becoming known to the officials whose business it is to hold these inquiries.

CAUSES OF FAILURE.

It will be seen from the appendix that in none of the cases has failure occurred through original weakness of the pipes themselves; that is to say, through their being originally made too thin. In the majority of cases the troubles have arisen through the design of the pipes having been at fault. In fourteen out of the sixty-eight cases referred to, the accident occurred through there being no provision for draining the collection of condensed water from the pipes; while in no less than thirty-eight, or more than half of the total accidents, there was insufficient provision for expansion and contraction, and for the motion due to vibration, etc., and in many of these cases similar accidents had previously occurred without being inquired into. In a few cases the explosions occurred either through original defective workmanship or through defects which subsequently developed in the pipes.

MATERIALS FOR PIPES.

It will be well to first consider the materials used for pipes before dealing with the question of design, as the latter has to be made to suit the materials employed. The materials in general use for main steam pipes are copper, used either in the form of seamless or of brazed tubes; wrought iron, generally lap-welded; steel, also lap-welded, and sometimes fitted in addition with a riveted butt strap covering the welded joint; cast iron has been employed in a few cases, as also has seamless steel. Small steam pipes for auxiliary purposes are almost invariably made of copper. In a few

*A paper read at the Fourteenth Session of the Institution of Naval Architects, London.

cases, however, they have been made with seamless steel.

COPPER FOR STEAM PIPES.

Of these materials copper is by far the most common. Formerly nearly all copper pipes were made from sheet copper, with brazed lap joints; straight pipes, except in the largest sizes, being made with one seam. Bends of small pipes are generally made from straight tubes; large bends, however, are made from two sheets, worked into shape by the coppersmith, and brazed along two seams. Recently, improvements in manufacture have enabled seamless tubes to be made at reasonable prices, so that, up to about 6 or 7 in. diameter, most steam pipes are now made from seamless tubes, which are bent by the coppersmith into the shapes required. Generally the flanges are brazed on the pipes, but in a few cases special patent flanges are adopted, enabling brazing to be dispensed with. That want of confidence is felt in copper pipes by the Admiralty and by some engineers is shown by their wrapping them with copper wire, or by steel wire rope, or by fitting wrought iron bands at short distances apart along their whole length.

Copper probably owes its present extended use mainly to custom, and its first selection was, no doubt, due to its non-liability to corrosion and to its great ductility. The latter, however, is a variable quantity, depending largely upon the treatment to which it has been subjected, and depending also upon its composition. When copper has been thoroughly annealed it is very soft, and a very low stress, say, even less than two tons per square inch, will produce a slight permanent set. As the stress increases the deformation increases more rapidly, and at a tensile stress of from 13 to 14 tons per square inch, calculated from the original section, fracture will take place. In the case of good copper, which has been previously properly annealed, the elongation in 8 in. will be about 30 to 40 per cent. If the copper is stressed to any less amount than its ultimate strength and the load released it will be found that the stress has *hardened* the copper, and that the metal will then be practically elastic up to nearly its original load, less stress than this producing no further permanent elongation. If, after this hardening, the copper is again annealed it will behave as it did in its original annealed state, a low stress again producing a permanent elongation.

STRENGTH OF COPPER PIPES.

The effect of hardening upon the extension, and the apparent ultimate strength of copper, is well illustrated by the accompanying autographic diagrams of tests made by Professor W. C. Unwin on specimens of copper, one being annealed and the other fairly hard. Fig. 1 represents the tests on the annealed, and Fig. 2 upon the other specimen. In these figures vertical distances represent the total load upon the specimens, and horizontal distances represent upon a scale of twice the full size the elongation in an original length of 8 in.

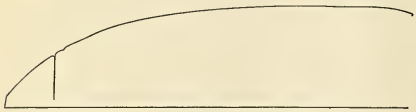


FIG. 1.

The particulars of the actual tests are given in the table below:

Dimensions.		Section.	Stress at Elastic Limit.	Maxim. Stress in Tons.	Elongation in 8 in.	Remarks
Width.	Thick.					
In.	In.	Sq. in.	Tons per sq. in.	Per sq. in.	Per ct.	
1.503	0.188	0.2826	1.769	13.03	48.13	Annealed
1.498	0.193	0.2891	15.56	16 13	17.88	Hard.

The nearly vertical line at the commencement of each curve shows that the elasticity of the material was at first nearly or quite perfect; the falling away of the curve from the vertical portion shows the elongation which takes place after the elastic limit is passed. In the case of the hard copper it appears that after the material has commenced to stretch the application of the same load continues to elongate it. In the case of the soft specimen, a low stress commences to stretch it, but until nearly half of the total elongation is reached each successive increment of stretch requires a higher stress to produce it.

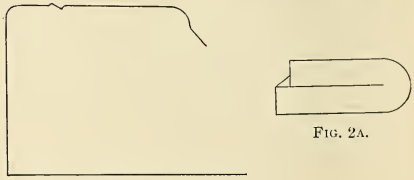


FIG. 2A.

FIG. 2.

The break in the curve was produced by relieving the stress after an extension of one-third of an inch. On the load being re-applied, it will be seen that the elastic limit had been raised by the previous testing from 1.769 to 6.9 tons per square inch.

The lower ultimate strength shown by the annealed piece of copper is due to the stress being calculated from the original area, the great extension of the soft specimen causing more contraction of area than occurs with the harder specimen. If the stress actually borne by the two pieces is referred to the actual reduced section at the moment when each is withstanding the maximum load it will be found that the results are approximately equal in these two cases. This shows the importance, when testing copper for the purpose of ascertaining its quality, of being careful that the specimen is properly annealed before the test.

Hardening of copper may be produced in other ways than by direct tension. Copper wire is hardened by continual bending and straightening; sheet copper is hardened by hammering or by cold rolling; pipes may be hardened by planishing or by being hammered or bent whilst they are "loaded," and copper tubes are always hardened when they are drawn on a draw bench either to a smaller diameter or to a thinner gauge. In whatever way copper is hardened, its ductility is correspondingly lessened, and in all cases the hardening may be

removed by "annealing," that is, by raising it to a bright-red heat, and either quenching it in water or allowing it to cool gradually.

Commercial copper, as used for other than electrical purposes, is rarely pure, or even nearly pure. The effects of some of the common impurities, such as arsenic, nickel, and silver, are supposed not to be detrimental; while, on the other hand, antimony is objectionable, and bismuth, even in small traces, is exceedingly prejudicial. The usual workshop test for the quality of copper is to cut off a portion of the pipe or sheet and anneal it, when it should stand bending quite close, without a sign of cracking, as shown in the illustration, Fig. 2a. The edges also should stand thinning to a knife-edge without crack when hammered to a scarf joint form with a lap of about three or four times the thickness of the copper.

BRAZING COPPER PIPES.

Brazing solder is composed of copper and zinc, in about equal proportions; occasionally, however, one-half per cent of tin is added to the mixture. The mixed metal is first cast in iron ingot molds, then it is reheated to a certain temperature, considerably below red heat, at which it becomes brittle and is pounded up with an iron pestle and mortar. The addition of the small quantity of tin is said to facilitate the pounding. It thus appears that at a temperature intermediate between that of the steam and a red heat the solder becomes brittle, and unfit to sustain any stress.

It is usually considered that the brazing solder, like copper, is not liable to corrosion, and in the majority of cases in which brazed copper steam pipes have been cut up after many years of service the brazing is found to be in as good condition as the copper. In a few cases, however, the brazing of copper steam pipes has been found to have deteriorated in use to an alarming extent. Attention was first drawn to this in the case of the fatal explosion of the steam pipe of the S. S. *Prodano*, referred to in the appendix as No. 1,033. After the official inquiry into the matter this case was investigated by Professor Arnold, of Sheffield, whose report was published in *Engineering*, Vol. LXV. p. 468, and *The Engineer*, Vol. LXXXV, p. 363. Professor Arnold showed that the brazing in this and in another case submitted to him at the same time had deteriorated by the whole of the zinc in some parts of the solder becoming oxydized, the copper remaining in the form of a spongy metallic mass, the pores of which were filled with oxydized zinc. He attributed this result to electrolytic action set up by fatty acids produced in the boiler or in the steam pipe from the decomposition of organic oils, as he found and separated these organic acids from the deteriorated solder. Since attention was drawn to these cases a few other steam pipes have been found to have been similarly depreciated in their brazing.

It is worthy of note that experience with Muntz metal exposed to the corrosive action of sea water shows that a somewhat similar deteriorization of the zinc takes place. It is said that this is prevented if a small quantity of tin is added to the mixture; but in the cases of the brazing solder investigated by Professor Arnold, one specimen, which originally contained one-half per cent of tin, was equally affected to that composed of copper and zinc only.

RECENT PUBLICATIONS.

MECHANICAL MOVEMENTS, POWER DEVICES AND APPLIANCES, *used in Constructive and Operative Machinery and the Mechanical Arts.* By Gardner D. Hiscox, M.E. Norman W. Henley & Co., New York. Size, 6 1-2 by 9 1-2. Pages 396. With 1,649 engravings. Cloth, $3.00.

This is a handy book of reference for the use of Inventors, Mechanics, Engineers, Draughtsmen, and others interested in any way in mechanics. For the first named it is specially valuable, for while it does not pretend to cover all the known forms of applications of mechanical principles, yet it treats of so many different mechanical forms and their uses that it is a good index of existing practice. A reference to its pages would often save the inventor many hours of useless study in working out what has already been accomplished. And, contrariwise, it will be found of much use by the designer or draughtsman, who can, in its pages, get ideas how to work out some problems in motion which may come up in the routine of design. The book is divided into sections as follows: The Mechanical Powers, Transmission of Power, Measurement of Power, Steam Power, Steam Appliances, Motive Power, Hydraulic Power and Appliances, Air Power Appliances, Electric Power and Construction, Navigation and Roads, Gearing, Motion, Horological, Mining, Mill and Factory Appliances, Construction and Devices, Draughting Devices and Miscellaneous Devices. These sections are subdivided into groups of similar appliances, each appliance being briefly described in a single paragraph, and illustrated, for the most part, with a line drawing. Within the limits of its size the book is very complete and for the greater part up-to-date.

The London weekly publication *The Yachtsman* has been increased in size, and typographical improvements have been adopted which make it now about the most attractive looking marine paper published in the United Kingdom. The number of illustrations has been increased also, and the publishers announce that it will be "more then ever interesting, practical and up-to-date and that the price (six cents weekly) will remain unaltered." With each issue a very fine half-tone supplement, printed on heavy coated paper, is issued. The subject is usually a yacht under full sail at sea.

A new monthly publication has been started in London under the title of *British Refrigeration and Allied Interests*, which for a new journal is one of the most complete we have received. It is upon the lines of a newspaper rather than a technical paper, and has been so arranged doubtless to meet the special requirements of the field it proposes to cover. As might be supposed, there is much space devoted to the shipment of meats on ocean vessels, and the terminal facilities for handling cargoes. Technical matters, while not put in the forepoint, are, however, not neglected, as in a recent issue there appears a special article on "Liquid Air" by Dr. W. Hampson, M.A., Oxon., which is adequately illustrated. The foreign subscription to this periodical is only 5s. a year, and to those interested in the marketing of perishable goods it would be very useful. The office of publication is Leadenhall House, London, E. C.

U. S. Torpedo-Boat Destroyer Stringham.

The U. S. S. *Stringham*, the first torpedo boat destroyer completed on the Atlantic coast, was put into the water at Harlan & Hollingsworth's yard, Wilmington, Del., on Saturday, June 10. The launch was particularly successful and though it took place in a drizzling rain the enthusiasm of the hundreds gathered about the ship was not dampened, for the boat took the water to the accompaniment of hearty cheers and well wishes. She was christened with the customary bottle of wine by Miss Edwina Stringnam Creighton, of Morristown, N. J., a granddaughter of the late Admiral Silas H. Stringham.

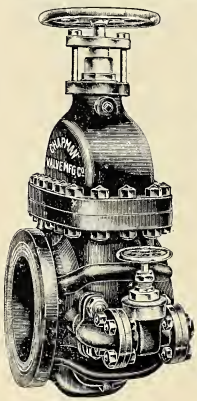
In our issue of February last a description of this vessel was given with drawings of the engines and hull. Her construction was authorized by Congress in the Act approved March 3, 1897, and the contract for her construction was signed with the Harlan & Hollingsworth Co., of Wilmington, Del., July 29, 1897. The keel was laid March 21, 1898, and the contract date of completion was set at July 29, 1899. The price for hull and machinery, exclusive of ordnance and outfit, is $236,000. She is 225 ft. long, 22 ft. extreme breadth, and at 6 ft. 6 in. mean draft displaces 340 tons. The design in its general features follows the English type of boat, but it is not a close copy of foreign plans. She has four Thornycroft water tube boilers, and three stacks, the two middle boilers having a common stack. The engines are twin screw, vertical inverted, triple expansion, designed to indicate 7,200 horse power, which is expected to drive the boat at least at the guaranteed rate of speed of 30 knots. Her allowance of coal at the normal draught of water is 35 tons, and her bunkers will stow 120 tons. She carries an unusually heavy battery for boats of her class, as in addition to two deck discharging tubes for 18-in. Whitehead torpedoes, she mounts seven 6-pounder R. F. guns, one on top of each of the two conning towers, and the other five on the deck between the conning towers. The officers' quarters aft consist of a cabin and state room for the Captain, a state room each for the executive officer and engineer, and a mess room, abaft which is a pantry and bath room. Forward of the Captain's quarters is a compartment with four berths for petty officers, and one with six berths for machinists. Forward of these is the firemen's quarters with twelve berths. Forward of the firemen's quarters is the engine room, occupying the full width of the boat for 28 ft., and then come the boiler compartments and coal bunkers, which absorb 73 ft. of the length of the boat. Forward of the boilers is the galley and then the crew's quarters, with twenty folding berths, and in the extreme bow the windlass compartment. A turtle back is built from the forward conning tower to the stern, and the latter has a sharp rake instead of being plumb as usual.

The boat was launched with the machinery in position and will soon be sent on her preliminary trial. She is one of the three destroyers contracted for in July, 1897. The other boats of this trio are the *Bailey*, under construction at Morris Heights, N. Y., and the *Goldsborough*, building at Portland, Ore. They are of smaller dimensions.

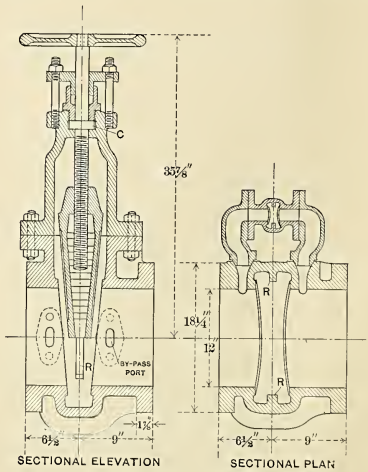
IMPROVED APPARATUS.

Steam Valve for Russian Battleship.

The accompanying cut shows a special 12 in. high pressure steam valve, recently built for one of the new Russian battleships by the Chapman Valve Manufacturing Company, of Indian Orchard, Mass. This valve is designed for a working steam pressure of 256 pounds per sq. in., and is made entirely in bronze, including the hand-wheels, bolts, studs, and nuts. The valve is of the standard double faced solid wedge plug type originated by this company, and is of extra heavy pattern with ribbed body. The gate, or plug, is in one piece, made hollow and wedge shaped or tapering, heavily ribbed internally. The seats are integral with the body and at an angle of 10 deg. with each other. To insure perfect alignment with the spindle, the plug is guided by ribs or splines in the body (*R.R.* Figs. 2 and 3) which engage with grooves in the edges of the plug and prevent it from turning or coming into contact with its seats while opening or closing. The valve is of the inside screw type and the plug rises and falls on the spindle, its upper portion being threaded to form a nut for the screw on the lower end of the spindle.

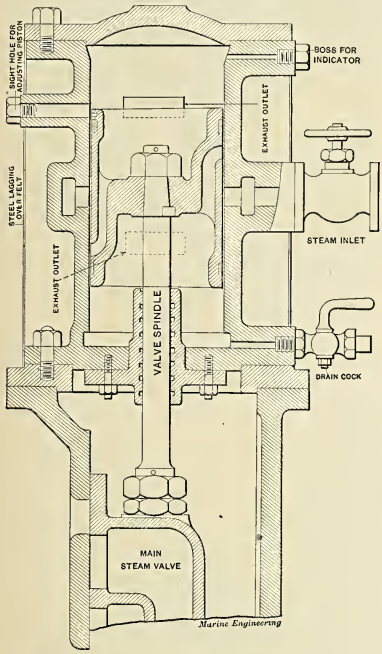


CHAPMAN VALVE.



SECTIONS OF CHAPMAN VALVE.—FIGS. 2 AND 3.

The spindle revolves but does not rise, being held vertically by the thrust collar *C*, and the valve thus requires much less room for operating than the outside screw type, in which the spindle rises with the plug. To furnish means for warming the pipes and to equalize the heavy pressure (about 29,000 pounds on 12 in. circle) before opening, the valve is provided with a special 1 1-2 in. by-pass, as shown in the engravings. The by-pass valve is of the same general type as the main valve. The by-pass pipes are of heavy bronze, with flanged connection to the by-pass valve and ground joint connection to the main valve body. The



JOY'S ASSISTANT CYLINDER.

main valve body is of special construction, being very short on one end. The stuffing-box is of ample size and has bolted follower. The wheels of both main and by-pass valves are of polished bronze. The bolts and nuts are of Tobin bronze, with navy bronze nuts. All other parts are of navy bronze. The neck of the valve cap is tapped for a 1-2 in. drip pipe, as shown in the woodcut. The valve was tested both open and closed under a hydraulic pressure of 500 lbs. per sq. in., and was absolutely tight under both conditions. The shipping weight of this valve was about 1,300 pounds. This company makes a specialty of high-pressure work, and also of valves for special uses, such as angle valves, drip valves and ammonia valves. These are chiefly of the "gate" type.

Joy's Assistant Cylinder.

In large engines with heavy slide valves, or in small, fast running engines where the momentum forces of the steam valves are considerable, the employment of some form of balancing piston is indicated. A modern development of the ordinary balance cylinder which has been widely adopted is the Joy assistant cylinder, a sectional drawing of which is here reproduced. About ten years ago this apparatus was first applied to the engines of a British war vessel, and though in rather an imperfect form, the advantages of it were so apparent that the inventor continued his investigations and experiments, until in time the present type was evolved. It is the purpose of this apparatus to support the weight of the valve, and to relieve the eccentrics and valve gear, as much as practicable, of the work required to move the valve. The apparatus, as plainly shown in the engraving, consists of a steam cylinder in which a piston works, this piston being secured to a prolongation of the main valve stem. The cylinder has steam and exhaust ports, and with the working piston forms in effect a little steam engine. Steam is admitted in the center of the cylinder and passes through ports cored in the piston to the ends. The piston in traveling opens the exhaust ports in the body, alternately, and the operation of the piston is thus automatic. The steam supply can, of course, be throttled, though when the main engines are linked in the assistant cylinder will be automatically and simultaneously affected. Power for "assisting" the main valves is obtained, of course, by the admission of live steam to the assistant cylinder, and the ports are so arranged that cushioning at the ends of the stroke in this cylinder absorbs the forces due to the momentum of the valve. In cases where the assistant cylinder has been long in use the wear on the valve gear has been very materially reduced, and the wear that has taken place has been very evenly distributed over the eccentrics, both top and bottom. Another advantage claimed for this apparatus over the ordinary balance cylinder is a substantial decrease in weight, a matter of special importance in vessels of the torpedo destroyer type. Owing to the greater efficiency of this apparatus a smaller size cylinder can be used. An instance of this is quoted where a 14 in. dia. balance cylinder, which, with piston and cover, weighed 604 lbs., was replaced by a Joy assistant cylinder of a total weight of 340 lbs.—a saving of about 56 per cent. The use of this assistant cylinder costs something in steam, but at the same time the work performed by the cylinder is taken off the main engines, and the direct application of steam to the movement of the main steam valve gives, necessarily, a higher efficiency than the same amount of energy applied through the roundabout way of the main piston, crank shaft and valve gear. A list of applications of this gear to modern vessels shows totals of 182 warships, representing 513,450 I. H. P., and 162 merchant vessels, aggregating 329,410 I. H. P. Such merchant lines as the P. & O., Cunard, American, North German Lloyd, Donald Currie and Orient are users, and among the navies are the British, Italian, Austrian, Spanish (Cristobol Colon), and Portuguese. The American representatives of the inventor are Thorpe, Platt & Co., 97 Cedar street, New York.

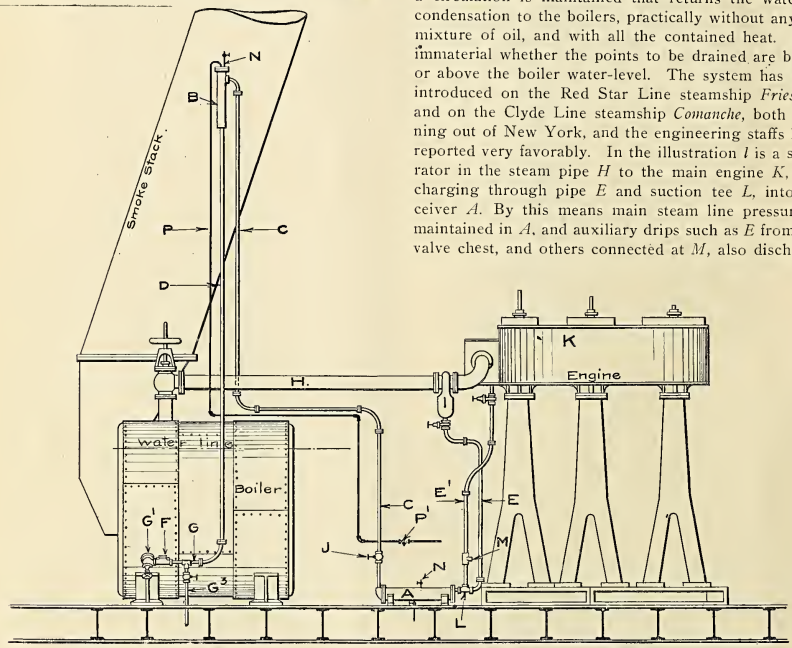
Ball Bearing Sheave Wheel.

Our engraving shows the Parkin Ball Bearing Sheave Wheel for use in tackle blocks, elevators, doors, slides and in all kinds of pulleys. The sheaves rotate without strain on the pin, prevent torsion on the straps, and remain clear at the sides of the shell when moving at any angle. For the equipment of yachts and sailing vessels this sheave is especially valuable, as running sails can be hoisted with considerably less labor than with the old-fashioned blocks, and, in dropping the sails without the use of a downhaul, the easy working of the blocks gives rapidity of action. Due to the easy running, the makers claim that where these blocks are used a great saving in ropes and tackle will result, and especially so in the case of heavy hoisting. As a result of practical tests a naval officer of prominence recently reported on these blocks as follows: "In my opinion the tests show that the Parkin Bushing is superior in simplicity, durability, and ease of working to the bushings now in Government use." The device is not complicated at all, for the sheave can be quickly taken apart by any ordinary seaman. The manufacturer is the Penna. Block Co., S.E. Cor. Seventh and Cherry streets, Philadelphia, Pa.

PARKIN BALL BEARING SHEAVE WHEELS.

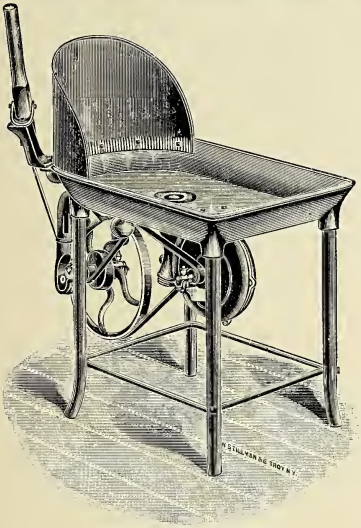
Holly Gravity Return System.

To automatically get rid of the accumulation of water in steam pipes and cylinders and valve chambers, in a steam vessel while under steam, is the object sought to be attained by the use of the Steam Loop and Holly Gravity Return System, a sketch of which is printed on this page. This system has met with great success in the shore plants, where it has been very extensively introduced. The manufacturers make strong claims for the effectiveness of this apparatus, and point to particular cases where its application has produced very beneficial results. On the score of economy alone its use is advocated, as it continuously conveys the water of condensation back to the boiler, thus utilizing this store of heat, the temperature of return water being as high as 300 deg. Fah. In this system advantage is taken of the force of gravity and the tendency of gases to flow to the point of lowest pressure. It continues in operation so long as any pressure is maintained, and independently of the use of steam for power purposes. Without the aid of feed pumps or other moving parts a circulation is maintained that returns the water of condensation to the boilers, practically without any admixture of oil, and with all the contained heat. It is immaterial whether the points to be drained are below or above the boiler water-level. The system has been introduced on the Red Star Line steamship *Friesland* and on the Clyde Line steamship *Comanche*, both running out of New York, and the engineering staffs have reported very favorably. In the illustration *I* is a separator in the steam pipe *H* to the main engine *K*, discharging through pipe *E* and suction tee *L*, into receiver *A*. By this means main steam line pressure is maintained in *A*, and auxiliary drips such as *E* from the valve chest, and others connected at *M*, also discharge



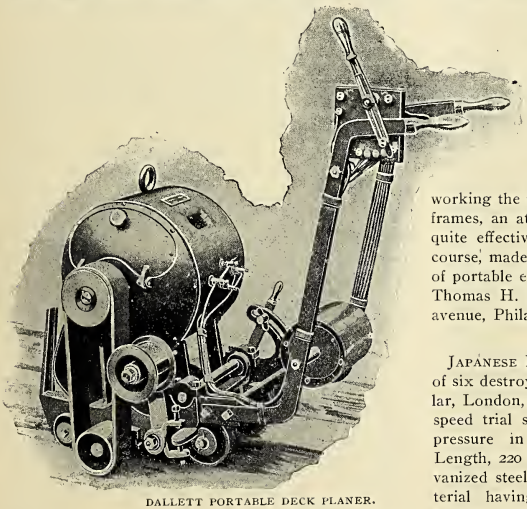
STEAM LOOPS AND HOLLY GRAVITY RETURN SYSTEM IN STEAMSHIP.

into *A*, through side opening of suction tee *L*. The riser *C* connects with the discharge chamber *B*, and



EMPIRE PORTABLE FORGE.

thus delivers back to the boiler or boilers through *D*. *P* is a small pipe connecting *B* with the condenser,



DALLETT PORTABLE DECK PLANER.

through a special reducing valve P^1, so that a slight fall in pressure may be maintained in *B*, to insure free circulation of the system. *NN* are air vents, and *G* is a blow off. Other valves shown are for properly controlling and operating the system. The system is controlled by Westinghouse, Church, Kerr & Co., Havemeyer Building, New York, who will be pleased to furnish fuller particulars on inquiry.

Empire Portable Forge.

For use in the open, where a hood is not required, the portable forge here illustrated has been specially designed. The hearth, which measures 23 in. by 35 in., is supported on stout iron pipe legs. Blowing is effected by a reciprocating motion of the handle at the back, so that the helper can readily urge the fire with one hand and manipulate the tongs with the other. The height of forge is 30 in. and the weight 145 lbs. It is guaranteed to produce a welding heat on 3 in. iron in seven minutes. For boiler, bridge and ship work it is especially adapted. Driving is effected by belts, and gears are thus avoided. The bearings are fitted with brass boxes and oil cups throughout, and the friction clutch is of the noiseless variety. If desired this type of forge can be had with attached water tank. The forge is manufactured by the Empire Forge Co., Lansingsburgh, N. Y.

Portable Deck Planer.

A novel machine for finishing wooden decks is shown in the engraving of what at first glance appears to be a freak lawn mower. This machine, in fact, not only resembles a grass cutting machine in appearance but in operation. The cutter head which carries the planing knives is belt driven from the pulley of an enclosed electric motor, which is carried on the top of the frame forward of the operator. The entire machine is carried on wheels fitted with roller bearings, and when the operator pushes the machine ahead the knives come in contact with the planking, and when he hauls the machine in a sternward direction the knives are raised off the deck. There is a ready adjustment for the regulation of the depth of cut, and the stopping and starting switch is very conveniently placed at the handles. For working the machine at the sides of a ship, close to the frames, an attachment is provided which is said to be quite effective. Connection with the machine is, of course, made with wire in the manner usual in the case of portable electric appliances. It is manufactured by Thomas H. Dallett & Co., York street and Sedgley avenue, Philadelphia, Pa.

Japanese Destroyer Akebono.—This vessel is one of six destroyers now building by Yarrow & Co., Poplar, London, for the Japanese Government. On her full speed trial she made 31.159 knots with 1 1-2 in. air pressure in the stokehold. Her dimensions are: Length, 220 ft.; beam, 20 ft. 6 in. She is built of galvanized steel containing a proportion of nickel, a material having a stencil strength of 40 tons. Her armament consists of two 18 in. topedo tubes, one 12-pounder, five 6 in. rapid fire guns. She is propelled by twin screws driven by triple expansion balanced engines. The boilers are of the Yarrow type built for 230 lbs. steam pressure.

MARINE ENGINEERING

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THAT the forward movement in American shipping is being recognized abroad by observant men is indicated by the words of Sir William H. White, Chief Constructor of the British Navy, in his presidential address before the British Institution of Mechanical Engineers in London recently. After referring to the nearly equal importance of the shipping interests of the United States and the United Kingdom at the outbreak of our Civil War, and the subsequent decline of our merchant marine, the distinguished naval architect said:

Signs are not wanting, however, that our transatlantic cousins are not content with this (the present) relative standing, and we may anticipate a renewal of the old competition which is another reason for taking heed to our methods and machinery, and neglecting no source of economy in either building or working ships.

Sir William White evidently sees the handwriting on the wall, for as surely as the need for ships exists so surely will the rightful position of this country on the seas be restored. We, however, may, also, well "take heed to our methods and machinery," so as to hasten the day. There are numerous influences at work now which are for good in this direction, though many methods and a vast amount of machinery will have to be changed or replaced before America is mistress of the seas. These influences crop out here and there, often in unexpected ways. We know of two instances quite recently, as widely apart as the Atlantic and Pacific coasts, where precedent and tradition were departed from in the construction of vessels, and radical improvements in design and construction adopted in each case with unqualified success. In other important lines of manufacture, it has long since become impossible to continue a method or model just because the ancestors of some one interested used the same means or form to secure results. In bridge work and in locomotive building, two branches of the steel trade which have recently invaded the British field and created a sensation, not yet subsided, neither time nor material is used for any but sound engineering reasons. That some one in the remote past successfully attacked a problem that now again presents itself is very creditable to the deceased, but is no sound reason why similar methods should be employed now. It may be that the method then adopted cannot be improved upon, but the chances are almost certain that the advances in scientific knowledge, in materials, and in process of manufacture, will indicate a newer method. A walk through some of our older established shipbuilding plants will convince anyone familiar with modern methods that Sir William White's words are applicable to us. The unnecessary rehandling of material, the employment of slow moving and obsolete tools, the poor general arrangement of the plant, and the use of empirical and uncertain shop methods are too commonly observable.

AT a recent meeting of the Institute of Marine Engineers in London, a very sensible statement was made by a Mr. Halliday, which is applicable to marine affairs here or in fact those of any maritime country. A paper had been read giving an account of the performance of two merchant vessels at sea, and before discussion commenced Mr. Halliday suggested that the Society endeavor to have papers prepared by chief engineers of sea-going steamers, so that the Institute might come into possession of "detailed and reliable information" as to the actual working of marine engines at sea. He added that the paper just read might not be of great interest to the sea-going members, but to shore engineers it was a "matter of extreme interest and importance." It is a well-recognized fact that most of the published matter, of value, concerning marine engineering is from the point of view of con-

struction rather than operation. There are sufficient reasons, if not good ones, for this. Engineers as a rule are not owners, and, consequently, they are not at liberty to follow the promptings of their professional instincts. Secrecy is the policy adopted by the great majority of owners, be they of a corporate character or individuals. Usually this is an "ostrich" policy, for the real condition of affairs is very frequently plain enough to those who have experienced eyes and wits. A laughable example of this occurred not long ago in a port not a thousand miles from New York. A set of collapsed furnaces were removed from an ocean steamer, and in the dead of night carted from the yard in a covered wagon. While, however, the policy of secrecy does not prevent a knowledge of the truth among a few, it does keep from the many a proper record of experiences, which, discussed with engineering knowledge, would without doubt produce almost marvelous results. After all, design and construction are only a means to an end—the successful and profitable operation of a steam vessel fully adapted to the requirements of its trade. One of the most successful of the Clyde builders owed his success, in large part, to the frequent conferences which he held with sea-going engineers. When viewed from a strictly professional standpoint the present conditions are not entirely creditable to the marine interests. Making a comparison with the medical profession for example, the members of which are pledged in honor to the strictest secrecy regarding the personality of their patients, it will be seen that the physician and surgeon lives in a more truly professional atmosphere than the engineer. Without revealing the identity of his patients, he gives the most minute details of ailments and methods of treatment, and so scientific advancement knows no stop. If owners would only adopt a more liberal attitude in this respect they would be the greatest beneficiaries, for the whole trend of engineering progress is toward added profits for the owner.

IN ocean passenger service the growth of the "intermediate" type of steamer is very noticeable. This is especially so in the transatlantic trade where the number of such vessels now engaged in the service is considerable. Others are building, including some powerful ships, which, although perhaps not strictly answering to the description of intermediate, are more closely related to this type than to the record-breaking liner. In fact so successful has this type of vessel become, and so popular with ocean voyagers, that it is a question whether it will not eventually supersede the record-breaker for regular transatlantic service at least. The word just used—"successful"—gives the reason for the extensive adoption of the intermediate type. The operation of a line of steamships is a commercial undertaking, and thus compels the management to face either success or failure. Record-breaking ships and record-smashing trips are fine things in their way, but they do not, as a rule, produce dividends and that is what a steamship company is or should be organized for. Any other policy is sure failure. It is a significant fact that the older and better established lines are not at present in the record-breaking business,—a form of money spending which is now almost exclusively undertaken by the Germans. They no doubt have good reasons for the continuation of a record-breaking policy, but in their case there are enough slower ships to keep dividends up to high water mark, and the advertising feature of the policy is undoubtedly of great value to lines which are endeavoring to push to the front. The case is not without its parallel, which can be found in the railroad service of this country. Nowhere is greater attention given to the question of speed on railroads than here, and yet the number of sixty-mile-an-hour trains is extremely small in comparison to the number of moderately fast, luxuriously equipped passenger trains in daily operation. It is largely a question of profits, and the fast express has to be paid for by the way freight. Among the British and American transatlantic companies at least, the tremendous speed competition of a generation ago has given place to effort in the direction of better accommodations at moderate fares. The intermediate type of vessel has size sufficient to give most comfortable passenger accommodations, and steadiness at sea, and the necessary propelling machinery can be housed compactly and will run with a minimum of disturbing effects. Operating expenses are small, for the bulk of freight and number of passengers carried, as compared with the record-breakers and, of course, first cost, interest and depreciation charges are proportionately less. The transatlantic voyager is, during the summer season at least, a person of more or less leisure, and a day or two on the water more or less is, for him, well offset by the greater personal comfort and the more moderate fare on the intermediate ship.

CORRESPONDENCE DEPARTMENT.

[*Communications on matters of interest to marine engineers, for insertion in the correspondence department, are solicited. These, wherever possible, should be supplemented by rough sketches or drawings, which will be reproduced, if necessary to illustrate the subject, without cost to the writer.*

Full names and addresses should be given, but publication of these will be withheld where requested.

We do not assume responsibility for the opinions expressed by correspondents.]

Query Concerning Wireless Telegraphy.

Editor of Marine Engineering:

In your June issue, in an article on the "Marconi System of Wireless Telegraphy," the author, Mr. Poole, makes the following statement (see bottom of first column and top of second, page 27):

It is plain from the foregoing that the transmission of signals by these waves is limited by topographical and physical conditions to a certain degree; if an obstruction, such as a hill or the curvature of the earth, intervene between the points of communication, the vertical wires at each end must be of such a height as to afford an unobstructed path between a considerable length of their upper portions.

In a popular article in the June "McClure's," by Cleveland Moffett, speaking of the signalling between the Prince of Wales' yacht and the Osborne House, the statement is made:

On one occasion the yacht cruised so far west as to bring its receiver within the influence of the transmitter at the Needles, and here it was found possible to communicate successively with that station and Osborne, and this despite the fact that both stations were cut off from the yacht by considerable hills, one of those, Headon Hill, *rising 314 feet higher than the vertical wire on the Osborne.*

Again, Dr. Erskine-Murray, one of the company's chief electricians, is quoted as follows in answer to the question: "Then the earth's curvature makes no difference with your waves?"

It has made none up to twenty-five miles, which we have covered from a ship to shore; and in that distance the earth's dip amounts to about 500 feet. (I should think 400 feet J. W. C.) If the curvature counted against us, the messages would have passed some hundreds of feet over the receiving station; but nothing of the sort happened. So we feel reasonably confident that these Hertzian waves follow around smoothly as the earth curves.

Question: "And you can send messages through hills, can you not?"

Easily; we have done so repeatedly.

Mr. Marconi himself is quoted as saying:

It is likely, however that a limit for *directed* messages will be set by the curvation of the earth. This stops the one kind *but not the other.*

At the same time Dr. Erskine-Murray says that a vertical wire eighty feet long will send a message twenty miles. Of course, with a transmitting wire of that height and a receiving wire of similar height there would be afforded an "unobstructed path" between sixteen or seventeen feet "of their upper portions."

I perhaps owe your magazine, as well as Mr. Poole, an apology for seeming to question his statements on the strength of those in a popular article, but I should not do so if it were not for the fact that the latter are based on authenticated interviews.

Newport News, Va. J. W. Clary.

Reply.

Replying to Mr. Clary's letter above, the writer begs to say that Dr. Erskine-Murray's statement concerning the non-interference of the earth's curvature is a little misleading, though unintentionally so. No difficulty has been experienced in signaling 25 miles, because vertical conductors about 100 ft. high were used at each end. The length of a right line tangent to the earth's surface, from origin on the surface to a distant radial line, in statute miles, is approximately equal to,

$$1.4164\sqrt{h}$$

where h is the height of the radial line from the earth's surface to the tangential line. Consequently a line 25 miles long would just clear the earth's surface, theoretically, if drawn between the extremities of two masts 78 ft. high. The error consists in taking into consideration the height of only one vertical wire; the fact that there are two doubles the signaling distance. Hence we have:

$$2.8328\sqrt{h} = d$$

for a line between two mast-heads h feet high and just touching the earth's surface half way; and conversely,

$$\left(\frac{d}{2.8328}\right)^2 = \left(.353d\right)^2 = .1246d^2 = h,$$

h being the height in feet of each mast and d the intervening distance in miles. Any length of wire above this height may reasonably be considered active under average conditions.

The seeming discrepancy between this formula and Marconi's statement that the signaling distance varies with the square of the height is due to the fact that the above formula does not take into consideration the effect of the increased number of magnetic lines obtained by increasing the height of the vertical wire.

Referring to the account of an alleged successful transmission between the Prince of Wales' yacht and shore points with hills intervening, the absence of specific data concerning other vital conditions renders a deduction valueless. Moreover, popular articles are notorious for slovenly statements which seemingly justify unexpected conclusions, whereas accuracy of detail usually presents a totally different proposition. Unless Headon Hill is situated on one of those peculiar geological formations which insulate masses above them from the mass of the earth, it is inconceivable to the writer that signals could be transmitted through the hill.

That the electro-magnetic waves or oscillations follow the earth's curvature, the writer respectfully declines to believe until actual demonstration proves it true. The waves are similar to sound and light waves, which we know travel in straight lines except when reflected, and there is, thus far, no reason to believe that the magnetic waves differ in this respect, except in degree. They are not so susceptible to reflection and refraction. Unless an intervening mass is sheathed with some bright substance reflection does not occur, and when it does it is only partial. And if the intervening mass be common clay, Marconi waves impinging upon it will surely be arrested and resolved into definite alternating electric currents. Perhaps Headon Hill is pure silica or is set in a silica basin. Perhaps it was out of the path of transmission and did not intervene at all. Cecil P. Poole.

New York, June 20, 1899.

EDUCATIONAL DEPARTMENT.

HELPS FOR CANDIDATES FOR MARINE ENGINEERS' LICENSES—BOILERS.

BY DR. WILLIAM FREDERICK DURAND.

In the general sense, any receptacle in which steam is generated by the application of heat is a boiler. A boiler must, therefore, contain three fundamental features: a place for the fire, a place for the water, and a division or partition between them. The great variety of boilers arises from the different forms which these features take, and the different manner in which they are arranged. The keynote of the development of steam boilers from the earliest forms is contained in the word *subdivision;* subdivision of the hot gases and of the water so that no particle of either shall be very far from the partition or *heating surface,* as it is called. If in addition to this subdivision provision is made for a definite flow of the hot gas along one side of the heating surface and of the water along the other in the opposite

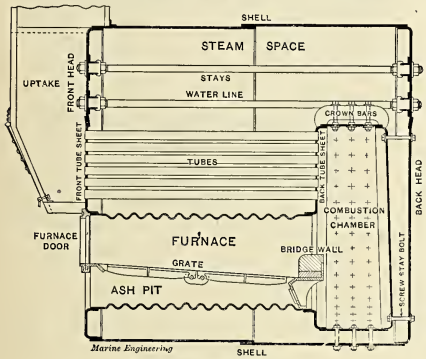


FIG. 1.—SCOTCH BOILER.

direction, the conditions for the most efficient transfer of the heat of the gas through the surface into the water will be fulfilled. In modern boilers the principle of subdivision has been carried to a high degree of development, but the conditions for proper circulation are but imperfectly fulfilled. The subdivision is obtained by the use of a large number of tubes or tubular elements surrounded by a shell or casing. The chief classification of boilers is made according to the relation of the water and hot gas to these tubular elements. If the gas is led through the inside and the water is on the outside, the arrangement is known as a *fire-tube* boiler. If, on the contrary, the gas is on the outside and the water circulates through the inside, the arrangement constitutes a *water-tube* boiler.

Fire-tube boilers may be divided into the *Return tubular* or *Scotch boiler,* the *Direct tubular* or *gunboat boiler,* the *Locomotive boiler,* the *Flue and return tubular* or *leg boiler,* and the *Flue boiler* as used on western river steamers. These are illustrated in Figs. 1-4.

Water-tube boilers are found in great variety, depending on the details of arangement of the tubes, and drums or headers of which they are composed. A few representative types are shown in Figs. 5-10. We will first give brief descriptions of the important features of these boilers, and then take up at a later point the subjects of their design and construction.

[1] THE SCOTCH BOILER.

In present practice, for marine purposes, the Scotch boiler is used more than any other one type, and, in fact, more than all other types combined. This boiler, as illustrated in Figs. 1 consists essentially of a cylindrical *shell* containing one or more cylindrical *furnaces,* usually corrugated circumferentially for strength, opening into *combustion chambers* at the back end, from which a large number of small *tubes* lead again to the front end or *head* of the boiler. The *grates* are placed at about the center of the height of the furnace, and the fire and hot gases occupy the upper part of the furnaces, the combustion chambers, and the inside of the tubes, while the water and steam fill all the remaining parts of the shell, the water level being usually some 6 in. to 8 in. above the highest part of the tubes or combustion chambers. The hot gases pass from the fire on the grate-bars into the combustion chamber, thence forward through the tubes and out through the *uptake* or *front connection* to the *smoke-stack* or *funnel.* Several varieties of this boiler are in common use. Thus the number of furnaces may be one, two, three, or four. They may be fitted with separate combustion chambers, or there may be one combustion chamber for all furnaces, or, as is common with four furnaces, there may be two combustion chambers—one for the two furnaces on either side. Again, the boilers may be *single-end* or *double-end.* Fig. 1, is an example of the first. A double-end boiler consists of two sets of furnaces opening from either end of a shell of double length. It is evidently equivalent to a pair of single-end boilers placed back to back with the back heads removed and the shells joined. Such boilers may also have either separate combustion chambers for each end, or a common combustion chamber for both ends. The former arrangement is to be preferred, and becomes necessary where forced draft is used.

[2] DIRECT TUBULAR BOILER, GUNBOAT TYPE.

This boiler is rarely used except in war ship practice, where with low head room it has been occasionally employed. It consists of a shell with furnaces and combustion chamber somewhat as in the Scotch boiler, but the tubes, instead of returning to the front, lead on to the farther head. To this head is fitted a smoke-box or uptake leading to the funnel. In such cases the boiler for the same power is of smaller diameter and greater length than the Scotch type, and it is readily seen that the whole arrangement is simply a mode of exchanging diameter for length.

[3] DIRECT TUBULAR BOILER, LOCOMOTIVE TYPE.

The locomotive type of marine boiler as illustrated in Fig. 2 consists of a cylindrical shell extended to the front and modified in form with flat sides and bottom, and flat or rounded top. The furnace is of rectangular cross-section, and is surrounded by the shell at the front, leaving on the sides a narrow space known as the *water-leg* and sometimes a like space underneath known as the *water bottom.* The gases take the same general course as in the gunboat type, the chief difference in the two being in the form of the furnaces and in the ab-

sence of the combustion chamber in the locomotive type.

[4] The Flue and Return Tubular or Leg Boiler.

In this boiler, as illustrated in Fig. 3, the hot gases pass from the furnace through large tubes or *flues,* as they are termed, to a combustion chamber at the farther end. They then return to the front through small tubes,

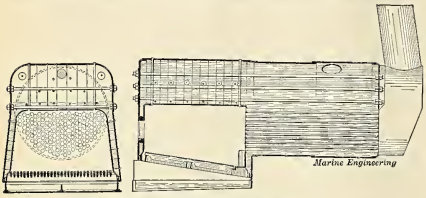


Fig. 2.—Locomotive type boiler.

and are led by an appropriate uptake to the funnel. The furnace is of rectangular cross-section, and the front end of the boiler is modified on the sides and bottom to correspond to this form, as in the locomotive type. Water legs are also formed in the same way on the

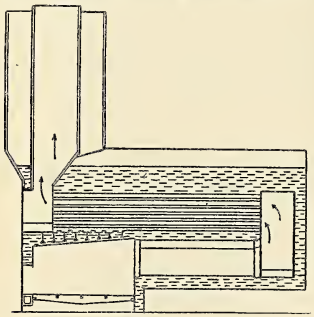


Fig. 3.—Leg boiler.

sides of the furnace, and from this feature the boiler receives its common name. This form of the front end of the boiler with flat sides and rounded top is sometimes known as a *wagon-top.* Very commonly, as shown in Fig. 3, an attachment to the shell, known as a *steam chimney,* surrounds the lower part of the funnel, the office of which is to subject the steam to the drying and superheating effects of the gases on their way through the funnel. Boilers of this type have been used to a considerable extent on tug and river boats.

[5] The Flue Boiler

In Western River practical use is commonly made of the return flue boiler as illustrated in Fig. 4. This boiler is eternally fired. The flames and hot gases pass back along the outside of the boiler to a back connection and then enter the flues and return through them to the front, and thence to the uptake and funnel. Boilers of the locomotive type, or tubular fire-box boilers as they are often called, are also used to a considerable extent in western river practice.

[6] Water Tube Boilers.

Turning now to this type, a brief description will be given of the leading features, which may be combined in the greatest possible variety, thus giving the vast number of forms of such boilers on the market at the present time. To aid in the description a few typical forms of such boilers are shown in Fig. 5.

Most boilers of this type have one or more cylindrical drums or chambers on top and one or more similar drums below, the two sets of drums being connected by sets of tubes. The feed usually enters first the upper drum, frequently passing on its way through a coil heater in the base of the stack or top of the boiler. It then flows down certain of the tubes to the lower drums. If these tubes are of extra large size and specially intended for down flow, the boiler is said to have special *down flow* or *down cast tubes* or pipes, as shown in Figs. 6, 8, 9. In some cases such tubes are omitted, and the feed must descend through part of the small inner tubes. In any case, after finding its way to the lower drum it enters the *up flow* or steam forming tubes, which are surrounded by the hot gases coming from the furnace below them. During the passage of the water upward it is partly converted into steam, and the mixture issues from the upper end of the tubes into the upper drum. There the steam is separated and led to the engine, while the water joins that already in this drum, and thus begins another round. In some cases the upper ends of the steam forming or delivery tubes are below the level of the water in the upper drum, and they are then said to be *drowned* or *wet.* In other cases they are above the water level and are said to be *dry.* In still other forms they enter at about the middle of the drum or about the water level, and may be *wet* or *dry* as the level varies. See Figs. 6 and 11 Water tube boilers are often divided into two general classes: *large tube* and *small tube* boilers. In the former they are

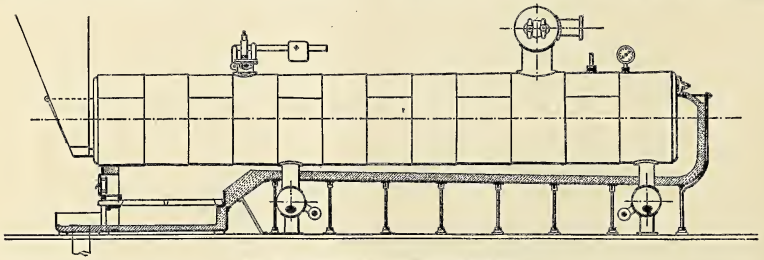


Fig. 4.—Externally fired flue boiler.

usually 3 or 4 or even 5 in. dia., while in the latter they are usually from 1 1-4 to 1 1-2 or 2 in. dia.

Again, the tubular elements may be made up in a great variety of forms. In some they are straight, as in Figs. 6, 8, 9, 10; in others, curved, as in Figs. 5 and 7. In small tube boilers they are very commonly curved or bent, while in the large tube types they are straight. Also in some types the elements are continuous between

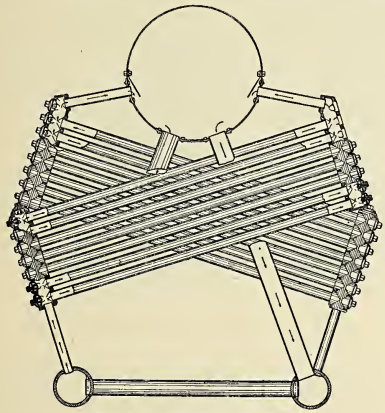


FIG. 6.—STRAIGHT TUBE TYPE.

drums or headers as in Figs. 5 and 7, while in others, as in Fig. 10, they are made up of lengths or of different parts with screwed joints, elbows, returns, junction boxes, etc. In some they are expanded into the shells of the drums; in others screwed. In some all joints are carefully protected from the direct action of the flame; in others screwed joints are freely exposed to the flame. In some the general direction of the tubes is nearly horizontal; in others nearly vertical, and in others bent or curved in various forms. In some types, as illustrated in Fig. 9, the lower drums are omitted, or consist merely of the lower portions of the tubes and *headers*, or members to which the tubes are connected. In all cases the grate lies below the tubes and frequently

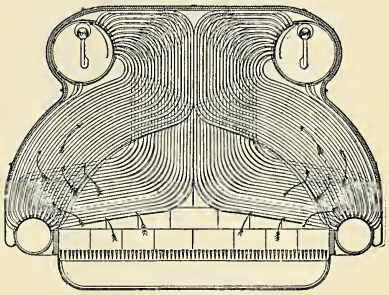


FIG. 5.—CURVED TUBE TYPE.

between the lower drums, as shown in Figs. 5 and 7; while the whole is surrounded by a casing intended to prevent, so far as possible, the loss of heat by radiation.

[7] RELATIVE ADVANTAGES OF DIFFERENT TYPES OF BOILER.

For large ships under ordinary conditions and where the extremes of lightness or of speed on a given displacement have not to be attained, the Scotch boiler

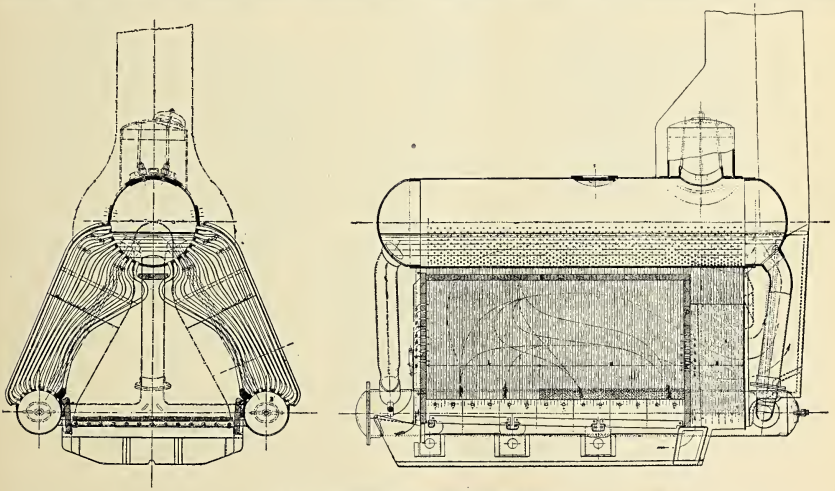


FIG. 7.—NORMAND WATER-TUBE BOILER.

seems at present to be considered as fulfilling most satisfactorily the all around requirements for a marine boiler, and in consequence it is found almost universally

in the mercantile deep sea marine, as well as on the Great Lakes and to a large extent on inland craft of all descriptions, except those of small size. It is also used extensively in naval practice on all craft except those of the torpedo-boat type, though the use of water-tube boilers is at the present time extending quite rapidly into this field, where their special features become of marked value.

For tugboats, river steamers, and a variety of small craft, the various types of direct fire-tube and flue boilers have been much used. These boilers are more readily adapted to a variety of demands regarding size, form and arrangement, and in small sizes are perhaps more cheaply built than Scotch boilers. In many cases, however, the preference for boilers of this type has doubtless depended on local and special conditions quite independently of their relative value from the engineering standpoint.

For fast yachts, launches, all craft of the torpedo-boat type, and in fact in all cases where the highest speed is to be attained on the least weight, the water-tube boiler has become a necessity, and in one or another of its many forms is universally employed. The weight of Scotch boilers without water per square foot of heating surface is usually from about 25 to 30 lbs.; of water-tube boilers of the lighter types from 12 to 20 lbs. The weight of the contained water per square foot of heating surface is usually from 12 to 15 lbs. for Scotch boilers, and from say 1.5 to 3 lbs. for water-tube boilers. It results that Scotch boilers with water will weigh from, say, 35 to 50 lbs. per square foot of heating surface, while water-tube boilers will similarly weigh from 13.5 to 23 lbs. These figures are not to be considered as giving absolute limits, but simply as representative values for average types. It should be noted, however, that a square foot of heating surface in a Scotch boiler seems to be somewhat more efficient than in a water-tube boiler. It is difficult to estimate the difference numerically, but other conditions being equal, it would probably be safe to give to the water-tube boiler additional heating surface to the extent of from ten to twenty per cent. On the other hand, it must be remembered that water-tube boilers can stand forcing to a much higher degree than fire-tube boilers. With the latter supplying steam to triple expansion engines the ratio of heating surface to I. H. P. can hardly be reduced below 2, while with the former this ratio has been reduced in many cases to less than one and one-half, and, as reported in certain extreme cases, to between one-half and one. Water-tube boilers have the further advantage that they are more readily constructed for the higher and higher steam pressures which modern practice is continually demanding. With water-tube boilers due to the construction and to the smaller amount of contained water, there is also less danger from disastrous explosion. With water-tube boilers steam may be raised much more quickly than with fire-tube boilers; from one-quarter to one-half hour is sufficient with the former, while from three to four hours should be taken with the latter.

Water-tube boilers are also much more portable than fire-tube. In many forms spare parts or even the whole boiler may be shipped in elements or sections across country by rail or to foreign ports by ship transport, put on board the steamer for which they are intended, and erected in place without difficulty.

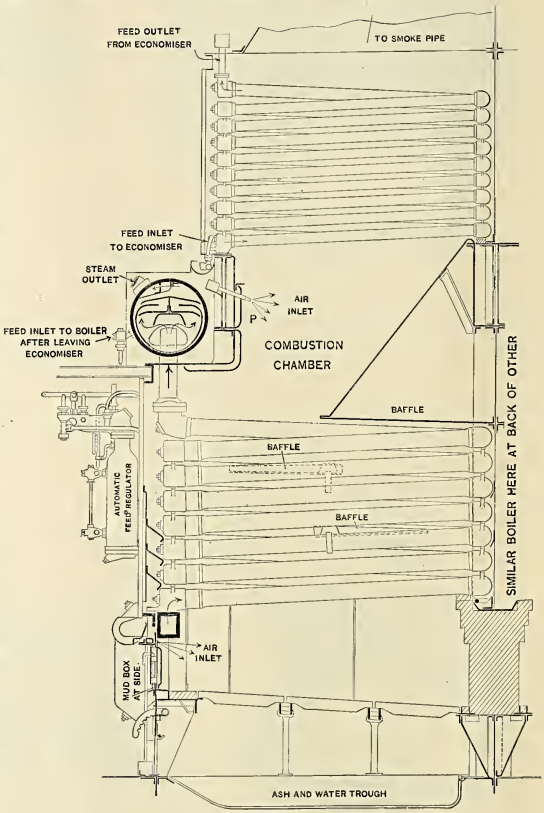


FIG. 10.—BELLEVILLE BOILER.

On the other hand, the water-tube boiler imperatively requires fresh water feed. Under modern conditions this should be provided no matter what the type of boiler in use, but if in emergency salt water must be used, the fire-tube boiler will receive the lesser injury.

Again, from the small amount of water contained as a stock upon which to draw, the water-tube boiler requires a more uniform feed than the fire-tube boiler, and is generally more sensitive to variations in the conditions under which it works. Again, the rupture of a tube is a more serious matter in the water-tube than in the fire-tube boiler. In the latter it may be plugged without disturbing the water and steam in the boiler, and with only a momentary interruption to its operation. In the former it is usually necessary to disconnect the boiler, draw the fires, blow down the water, and plug or insert a new tube. Water-tube boilers are also not readily made in large sizes or units. Scotch boilers may be made in 2,000 horse power units or even larger, while half of this or less is about the maximum for the water-tube boiler. An outfit of the latter for large power requires therefore a large number of boilers with a corresponding increase in the fittings and attachments. On the other hand, the temporary removal of one boiler for repair is of less importance, as the size is decreased and number increased.

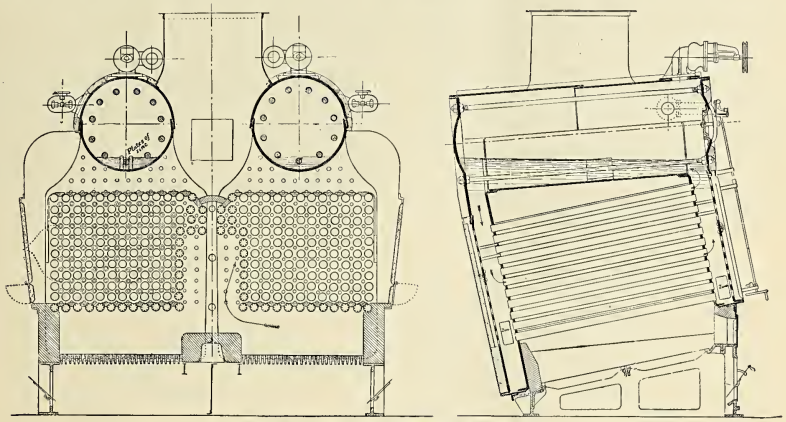


FIG. 9.—D'ALLEST WATER TUBE BOILER.

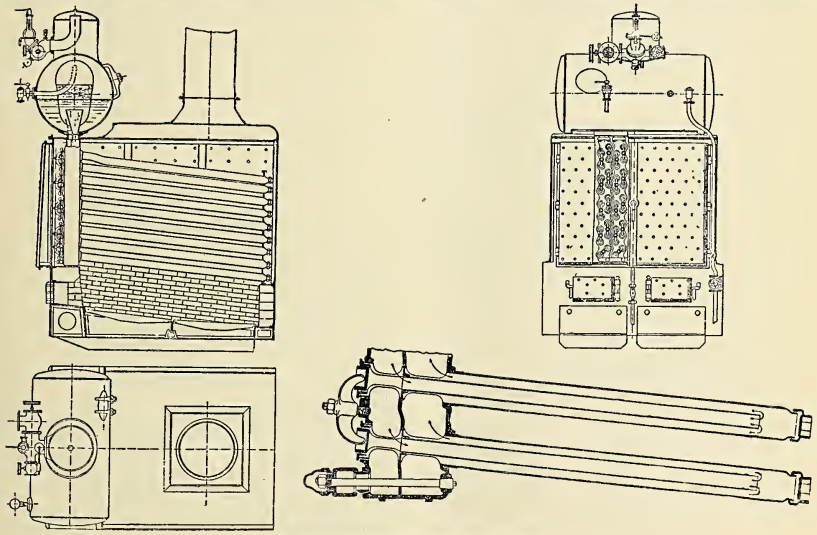


FIG. 8—NICLAUSSE WATER TUBE BOILER.

To summarize the general comparison between water-

tube and fire-tube boilers, the former have relative advantages in the following chief points: Weight, ability of feed, greater difficulty in dealing with leaky tubes, safety from disastrous explosion, and quickness of raising steam. On the other hand they have relative disadvantages in these points: A more rigid restriction of the feed to fresh water, the necessity of greater regularity of feed, greater difficulty in dealing with leaky tubes, and general sensitiveness to variation in the conditions of use, to which may be added the present feeling of uncertainty as to their durability and efficiency under the conditions prevailing on deep water voyages.

THE ART OF MAKING MECHANICAL SKETCHES —FOR MARINE ENGINEERS—VIII.

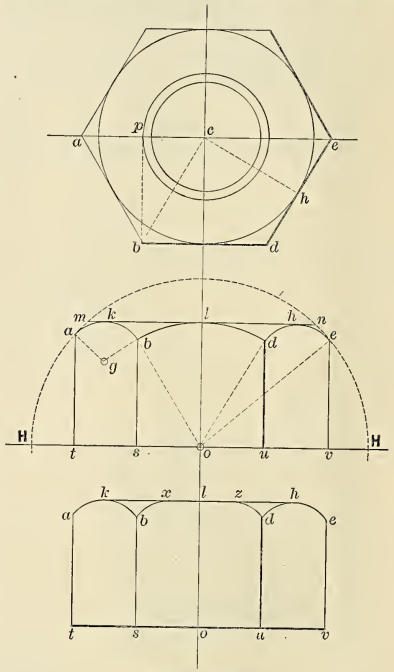
BY PROF. C. W. MAC CORD.

The idea is to some extent prevalent that in a mechanical drawing the representation of every detail must be accurately *constructed*, as though the object were to prove the draughtsman's knowledge of the laws of projection. This is by no means always the case—the object of a working plan is to show the workman what to make and how to make it; and usually it is desirable that the drawing should be made in as short a time as may be. In view of this latter consideration, we shall now proceed to illustrate some ready methods of representing certain details, by which much time may be saved, without at all impairing the practical correctness of the drawing.

The first example is that of a hexagonal nut, or bolt-head, which is shown as accurately constructed in Fig. 30. The axis of the hexagonal prism being vertical, the upper end of the nut is shown as finished off by turning it to the form of a spherical surface, which is very commonly done. Let H H represent a plane through *o*, the center of the sphere, perpendicular to the axis; then all the edges of the prism will pierce the sphere at the same distance from H H, so that the points *a*, *b*, *d*, *e*, all lie in one horizontal line.

The three visible faces of the prism will cut the sphere in three equal arcs of circles; of which the front one, *b l d*, being parallel to the paper, will in the front view be seen in its true form and size, its radius being *o b*. The other two, *a k b*, *d h e*, would strictly appear as arcs of ellipses; but these are of such small extent that approximating circular arcs may be used instead; it being noted that their middle points, *k h*, must lie on a horizontal line through *l*, to which line they are tangent, the radius, *a y*, may readily be found by trial and error. If the nut be cut off by a plane through *l*, as it often is, and is usually represented, the complete outline will also include the curvilinear triangles *a m k*, *h n e;* the portions *a m*, *e n*, being arcs of the circumference of the sphere. This has been set forth at length, because it may occasionally be worth while to represent the nut with all this precision of detail, as, for instance, in an elaborate "show drawing," or in the case of a nut of unusually large size. And it is to be noted that the height, *o l*, is equal to *o t*, half the "long diameter" of the hexagon (a very common proportion); also, that *s* bisects *o t*—because, as seen in the top view, the hexagon is made up of equilateral triangles similar to *a b c*, so that *b p*, perpendicular to *a c*, bisects *a c* at *p*, which corresponds to *s* in the front view. If, then, the long diameter, *v t*, be assigned, the points *t*, *s*, *o*, *u*, *v*, can be marked off at one setting of the scale, and *o l* at another; then the arc, *l b*, determines the heights of the points *a*, *b*, *d*, *e*, and *o e* is the radius of the arcs *e n*, *a m*.

Now, bolts used as fastenings, as for cylinder covers, valve-chest covers, etc., are seldom met with of a diameter greater than one inch and a quarter, except in very massive machinery; but a considerable number of that size or less have often to be shown on a single sheet, and that, too, upon a reduced scale. The small triangles, such as *a m k* of Fig. 30, would, then, be hardly perceptible unless drawn with most painful care; and



FIGS. 30 AND 31.

in such cases the short-hand method of Fig. 31 should be adopted. The little triangles are omitted, and instead of the single arc *b l d*, we draw two arcs, *b*, *x*, *z*, *d*, with the same radius as that of the arc *a k b*. This single radius, then, suffices for drawing all the curves of all the nuts of the same size, instead of using three radii for each nut, as in Fig. 30. Thus, it is shown that the corners are to be rounded off, which is all that the working drawing need indicate; and the saving in time is very great, which is a most important practical item.

And in drawing the hexagonal nut another point is to be considered—the proportion between its "long

diameter" and the diameter of its bolt. In the "standard" systems this proportion varies with the diameter of the bolt, and beginners are often afflicted with the idea that they are bound to conform to the tables; in consulting which they waste much valuable time. This is quite needless, for the workman looks only at the diameter of the *bolt;* if this be specified, as it always should be, the corresponding standard nut will be used, whether the drawing does or does not show it of the exact size. A very simple and ready rule, then, is this: For 1 1-4 in. bolts or less, make the long diameter of the nut twice that of the bolt, and for larger ones, 1 3-4 times; the height of the nut to be half its long diameter. And it may be well to recollect that the heights *t a, s b,* etc., of the points *a, b, d, e,* will then be practically 7-8 of the height of the nut.

In Fig. 32 two pieces are shown, fastened together by two bolts; the one on the left being a tap-bolt, the other a standing bolt, or stud. In the former the thread must extend a little above the face *a b,* its termination being made conspicuous by a dotted line; in the latter the thread should terminate abruptly at the surface, as shown. The thread is represented merely by the V's, as in making a section; the at-

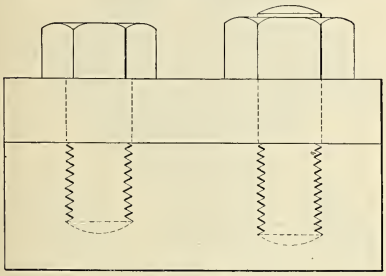


Fig. 32.

tempt to dot in the top and bottoms would result simply in a confusing mass of dots. In drawing the V's the triangles should not be used; having first drawn lightly in pencil two guiding lines, the V's should be drawn freehand in ink at once, using a fine steel writing pen. Nor need the V's be measured—with a little practice all the accuracy needed in a working drawing can be secured by the eye; the movement is simple, a light up stroke being followed by a heavy down stroke, as nearly at 60° to each other as may be, and as regular as possible; in order to avoid a tendency to round off the angles the pen should be lifted off the paper at each stroke.

A bolt is very seldom of such size as to call for the accurate construction of the helical curves of the threads; but sometimes it is desirable to make a drawing like that shown in Fig. 33. Here the V's are carefully laid out with the triangles, but "full sharp" and not flattened at top and bottom; the crests and roots are then drawn as right lines—the former heavier than the latter, because the crests cast shadows.

But even this amount of labor need hardly ever be expended in a working drawing; for bolts of small and medium sizes the mode of representation illustrated in Fig. 34 answers all purposes. Here no attempt is made at drawing the V's—the outer line of the bolt is drawn *in full,* and the threads are indicated by drawing a long and a short line alternately, the former being the

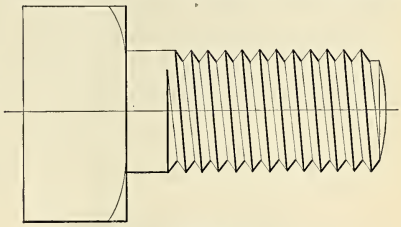


Fig. 33.

thicker, since it represents the crest, which casts a shadow, as above mentioned. The length of the short lines should be limited by two guiding lines drawn in pencil, as was the depth of the *V s* in Fig. 32; and their inclination may be readily determined, as in the diagram at the right; *m, m,* here represent the guiding lines just mentioned, and *b a c* is the section of a thread; then, since the root on one side is opposite the crest on the other, *c* is projected "square across" to *d,* and *a d* is the required inclination. The triangle being set by this, the lines may be spaced by the eye, just as in sectioning. Be it understood that this is a purely conventional *indication,* and does not pretend to be a *drawing,* of the screw; nevertheless, it will, unless quite large, look more like one than a correct drawing can be persuaded to, without wasting a prodigious amount of time and labor.

The preceding relates more to instrumental drawing than to sketching; what follows is equally applicable to both. Fig. 35 illustrates an important rule, to which there are very few exceptions, and that is, that *the continuity of masses of metal in sectional drawings should not be interrupted for the purpose of showing fastenings.* The figure represents a portion of a cylinder with its flange and cover; and the leading idea is to show at a glance the thickness and the breadth of

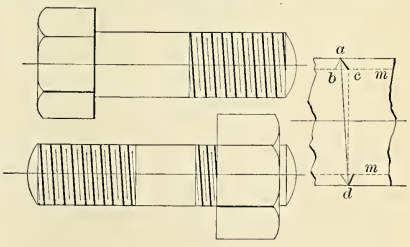


Fig. 34.

each of the flanges forming the joint. The cylinder and the cover must, of course, be fastened together, and the bolts are made for that purpose; but they should not be made unduly prominent.

A very common and a very faulty method of showing the same thing is given in Fig. 36; and those who adopt it urge in defence that it is the only correct way, since the bolt lies in the plane of the section. But the effect is very much as if the bolt were the most important item, and the cylinder and cover had been made chiefly for the purpose of using it. Still worse, two little portions of the flanges are thus isolated, like islands off a headland; so that the main idea is neither as clearly nor as forcibly expressed as in Fig. 35, while the labor of making the drawing is greater.

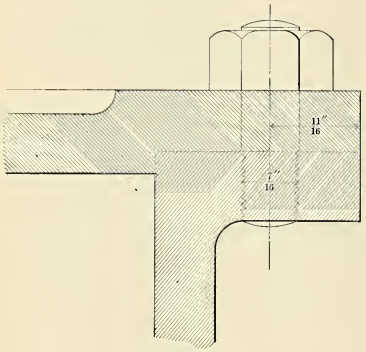


Fig. 35.

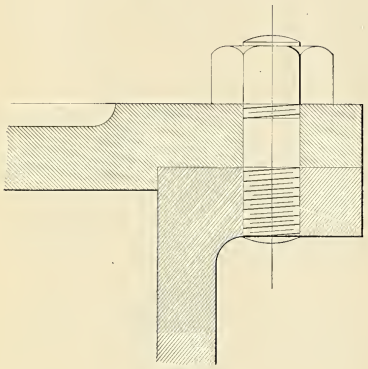


Fig. 36.

Now, whether the bolt lies in the plane of the section or not, it is certain that no misunderstanding can arise from using the first method, because the number and location of the bolts will be shown in the end view, and cannot be shown without it.

The same principle is illustrated in Fig. 37, which shows one arrangement of a double-riveted joint between two wrought-iron plates. This should be drawn as in A; if the rivets are drawn in full, as in B, each sheet is cut into three detached parts in the sectional view, so that the extent of the lap, which is of prime importance, is not made to catch the eye at once, as it should, but requires a little study and mental arithmetic for its full realization. The relative proportions of the principal parts, in short, should be made as conspicuous as possible; and in the representation of such joints there is nothing which could make them *less* conspicuous than to cut them up into little pieces, as in Fig. 36, and in B of Fig. 37. Reverting now to Fig. 35, it is to be noted that the diameter of the bolt is figured in, and also the distance of its center line from the edge of the flange, which should always be done, even in full-size drawings. This side view, again, shows whether the nut is to be square or hexagonal; consequently, in the end view it is only necessary to draw the bolt-holes for the purpose of showing their number and arrangement. It is a common and a melancholy thing to see all the *nuts* carefully drawn in the end view, and with equal care projected back to the side view and drawn in there. All of which is no less than a wicked waste of time; no one can tell from the side view how the bolts are spaced, and no one cares how they would look in that view. So again, the side view of one nut shows that it is in this case hexagonal, and

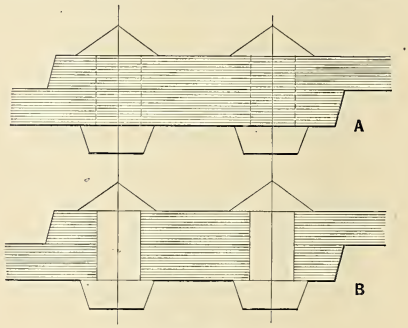


Fig. 37.

nothing is gained by drawing the end view of it and its companions. This general principle, then, should be clearly grasped and tenaciously retained—that *each view should be made to tell all that it can with certainty, but should concain nothing not worth showing.*

In the new monthly publication *Ueberall* the increasing interest which the German people are manifesting in marine affairs is fitly expressed. A very striking design has been adopted for the cover representing "Germania" pointing towards the sea, and beneath the words "Unsere Zukunft liegt auf dem Wasser" (Our future depends upon the sea). The new publication is the organ of the German Naval Society, founded April 30, 1898, under the Patronage of Prince Henry of Prussia, and its object is to further the interest of German Naval affairs. The articles are written in popular style, though technically correct, and there is a splendid profusion of half-tone illustrations. The periodical is edited by Commander Herman Gercke, I.G.N., and is published by E. S. Mitler & Son, Kochstrasse, Berlin, Germany.

ENGINEERS' DICTIONARY—XIX.

Furnace Bridge. See *Bridge-wall.*

Furnace Crown. See *Crown-sheet.*

Furnace Door—A door in the furnace front serving to open up the furnace to the fire-room Through this door the coal is thrown by the shovel, and the cleaning and working of the fire are carried on as may be required. The furnace door is usually of double thickness of metal with air space between, the two plates being provided with a certain number of small holes for the admission of air above the grate.

Furnace Front—A framework fitted to the front of the furnace and carrying the furnace door or doors.

Fusible Plug—A plug of fusible metal, usually Banca tin, placed in the highest part of the heating surface of a fire tube boiler. So long as the plug is covered with water its temperature will not rise to the melting point, and it will remain in place. Should

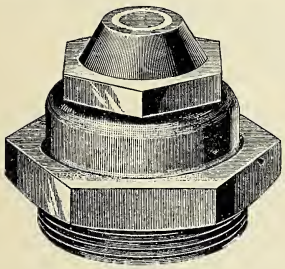


Fig. 75.

the water fall below, uncovering the plug to steam on one side and fire on the other, its temperature will rise and it will melt, giving notice of the low water by the escape of the jet of steam. In Fig. 75 is shown a composition plug fitted for screwing into the heating surface at any convenient point, and having a core of fusible metal extending through it as shown.

Gab-Lever—In the ordinary types of beam engine the valves are worked from a rock-shaft, extending across the front of the engine. This rock-shaft has an arm carrying a pin to which the eccentric rod hook is connected. This arm is known as the gab-lever.

Gallows Frame—The frame work which supports the beam of a beam-engine. See under *Engine*, Fig. 59.

Gasket—Sheet packing cut to shape and used to make a tight joint in such places as manhole covers, valve-chests, condenser bonnets and pipe flanges.

Gauge—A general name for instruments used for measuring, usually pressures or the height of water in a boiler, feed tank or other closed chamber. Thus *steam-gauge* for measuring the pressure of the steam, *water-gauge* for showing the level of water in the boiler, etc. See also *Air Gauge.*

Gauge Cock—A cock attached to the chamber of a boiler water-gauge. The gauge cocks are usually three to five in number, arranged with vertical intervals of a few inches. They serve to show independently of the gauge glass the approximate level of the water in the boiler. In some cases they are attached directly to the boiler or chamber containing the water.

Gauge Glass—A glass tube forming part of a water gauge, the latter being connected at the bottom to the lower part of the boiler or other chamber containing water, and at the top to the upper part. The water will then stand at the same level in both tube and boiler, thus showing to the eye the height of water as desired.

Gauge-Pipe—A pipe connecting a gauge with the boiler or other chamber, within which the pressure or height of water is to be measured.

Gate Valve—A valve for closing or regulating the opening in a pipe. The moving part of the valve consists of a slide moved by a screw back and forth across

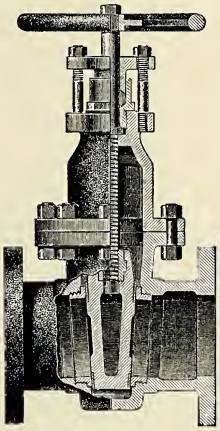


Fig. 76.

the opening of the pipe. See Fig. 76, in which the valve is closed. It will be noticed that when the valve is wide open there is an unobstructed passage, for the gas or liquid, through the valve.

Generator—A common name for a dynamo—a machine for generating an electric current. The term *generator* is also frequently used in referring to boilers of the water-tube type.

Grease-Cock—A cock placed in the shell of a boiler near the water line, and through which the grease and scum which collects near the surface of the water may be blown into a connecting pipe and thence overboard. This arrangement of cock or valve and pipe is more commonly known as the *surface blow.*

Grease Cup—A cup containing grease for lubrication, and from which it feeds to the place where needed, either as it is forced by a piston or plunger urged by a spring, or as it is melted by the heating of the part requiring lubrication.

Grommet—Packing consisting usually of a few turns of cotton-wicking or similar material, placed under the head of a bolt to prevent leakage when the bolt is drawn into place.

QUERIES AND ANSWERS.

Communications intended for this department will not receive attention unless accompanied by the full name and address of the sender, which will be considered confidential.)

Owing to a typographical error the formula for finding the diameter of boat davits was incompletely given in the May issue. The correct formula reads:

$$d = 2.2\sqrt[3]{\frac{AW}{P}}$$

EDITOR.

Q.—Please publish a rule for setting slide valves in duplex donkey pump. NORTH CAROLINA.

A.—Steam pumps may be divided into two classes—first, those in which the steam is used expansively, and second, those in which the steam follows full stroke in the steam cylinder.

The first variety is usually equipped with a crank-shaft and fly-wheel, which are driven either with a slotted link or connecting rods. As the pressure in the water cylinder is constant throughout the stroke, the momentum imparted to the fly-wheel assists the steam piston after cut-off has taken place in the steam cylinder, with the resultant diminishing of pressure in the same. This style of pump is often used in city water pumping plants and for other purposes where large quantities of liquid are pumped against a comparatively constant pressure, and where economy of steam is important. For smaller sizes of pumps this style has been abandoned, owing to the excessive weight of the fly-wheel, large space and foundation required, and the inability to control the capacity within large limits. The steam valves of fly-wheel pumps are driven by an eccentric on the crankshaft, and in all respects are the same as the valves on an ordinary steam engine.

The second class of pumps may be subdivided into two classes:

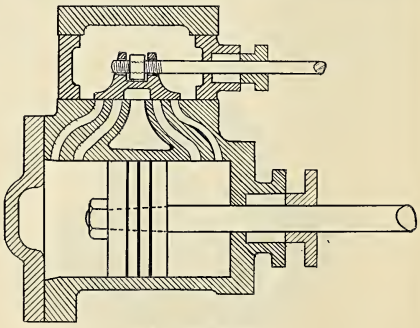
First. The so-called single cylinder pump, in which the steam valve is indirectly actuated by its own piston rod, and, Second, the duplex type, consisting of two steam cylinders, in which the valves are each actuated by the piston rod of their adjoining cylinders. The duplex type must not be confounded with the frequent twin arrangement of single cylinder pumps where each cylinder works entirely independent of the other. In both of these types the steam follows full stroke in the cylinder, and therefore it is evident that the valves do not require either steam or exhaust lap, and in practice only a small amount is given—just sufficient to make them steam tight. The valve mechanism is so designed that the valve is shifted at the end of each stroke so as to uncover one steam port and exhaust through the other.

In a single cylinder pump this motion could not be obtained directly from the piston rod, as the piston is momentarily at rest when it is time to shift the valve. To produce the desired effect an auxiliary valve is adopted, working directly from the piston rod, and which is usually of the ordinary D form or equivalent. Directly attached to the main valve is a long piston working in a cylinder in the main valve chest. When the steam piston approaches the end of its stroke the auxiliary piston is mechanically shifted by gear from the piston rod, admitting steam to one side of the auxiliary piston, containing the main valve, causing the latter to shift. This explains in a general way the action of the so-called single pump, although there are many modifications of the type and directions for adjusting and setting of valves for one particular make of pump would not apply to others.

The duplex pump requires neither auxiliary valve nor auxiliary piston, for when one piston is momentarily at rest at the end of its stroke its valve is shifted by the motion of its neighbor, which has not quite finished its stroke.

As stated in the foregoing, the proper motion to be imparted to a steam valve is to shift it when the piston reaches the end of its stroke. To accomplish this there is a certain amount of lost motion to be given to the valve. This can be produced by means of a tappet, worked from the piston rod and sliding between adjustable collars on the valve stem, giving the valve a push at the end of each stroke. Another and more common way is to drive the valve rods uniformly from the crossheads by means of links and levers, the lost motion being effected by adjustable nuts where the valve stems pass through and are attached to the valves. In some of the most modern duplex pumps these adjustable nuts and also the tappet collars have been discarded, and in place of them the valve is cast with a yoke on top containing a square block, which is attached to the valve stem. This block drives the valve and fits loosely between the jaws of the yoke, according to the amount of lost motion required. The exact amount of lost motion can only be determined by trial. Too little lost motion will reduce the stroke of the pistons, and too much of it will increase the stroke to the extent that the steam pistons will strike the cylinder ends, thus covering the steam ports and causing the pistons to stick fast, as the steam cannot get behind them.

In adjusting the valves of a duplex pump it is necessary that they throw equidistant from the center of the seat, and that



STEAM END OF PUMP.

both valves are set exactly the same, as the false setting of one valve will make the adjoining cyclinder work erratically, as well as its own.

Large pumps are usually fitted with two steam ports at each end. The outer steam ports enter the cylinder directly at the ends and the inner ports a certain distance from the ends. The valve works the same as for the single ported type, except that the outer ports are for steam entrance only and the inner ports only for leading exhaust steam from the cylinder to the regular exhaust port of the valve. When the steam piston arrives near the end of its stroke it covers the exhausting port, and as the steam left in the end of the cylinder has no outlet, it will act as a buffer on the piston, thus preventing it from striking the ends. So-called cushioning valves are fitted to each end of the cylinder, controlling openings between the double ports, whereby the amount of cushioning can be easily increased or diminished. In the accompanying sketch the working parts of the steam end of a pump are shown.

The twelfth annual edition of Beeson's Marine Directory, for the season of navigation, 1899, is received. This standard book has been thoroughly revised and brought down to date. It contains a great variety of information for the use of Owners, Agents, Manufacturers, and Supply men, including: List of American steam vessels on the Lakes, Vessel owners, Record of Engines and Boilers, Miscellaneous matters of interest. Soo Canal statistics, Iron Ore Output, Descriptions of American Lake Ports, Insurance Ratings, Classified directory of trades, and a great variety of minor matters. The book is well bound and printed, and is a very valuable work of reference. It is published by Harvey C. Beeson, Royal Insurance Building, Chicago. Price, $5.